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FUNCTIONAL ROENTGEN DIAGNOSIS: ANATOMICAL IMAGE—PHYSIOLOGICAL INTERPRETATION*

CALDWELL LECTURE, 1958

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As I think of the list of distinguished scholars who have delivered this Lecture, in honor of Doctor Eugene Caldwell, I am conscious of the responsibility which I bear tonight. May I thank Doctor Young and the Society for this privilege and honor. We, who have been fortunate enough to have participated in the Golden Age of Radiology, can only look back with awe upon those intellectual giants who founded an infant science and bequeathed us a highly developed specialty. Amongst these, none had a greater role than Eugene Caldwell. During a most difficult period in the evolution of the roentgen ray as a useful diagnostic instrument, his accomplishments, his contributions, were immense. I could not, even if I would, embellish or enrich the tributes paid to Doctor Caldwell by his friends and contemporaries, Preston Hickey[5] and Percy Brown.[2] Their description of his career and of his contributions are worthy of the careful perusal of every radiologist.

IN A Lecture honoring a great man, it seems appropriate to present a somewhat philosophic point of view. Particularly, is this true when one arrives at the venerable age of three score and beyond; for, one of the privileges of seniority—I almost said senility—is to indulge in philosophical conjecture, to attempt to translate experience into words, to try to organize some area of knowledge into a homogeneous mass. I feel I am entitled to the privilege of not presenting any new or startling discovery tonight. What I should like to offer is a re-emphasis on a method of roentgen interpretation. My purpose is to stress the place of physiology in roentgen diagnosis, to thrust forward the importance of function and how it can be interpreted from the static image in the roentgenogram.

It is possible to look upon the development of roentgen diagnosis as a series of stages. Curiously enough these are strikingly reflected in the career of Eugene Caldwell. There is first the period of technical development, invention of equipment. Then comes a period of pure anatomical identification. Caldwell, the electrical engineer, who first invented equipment, found it necessary to take a course in anatomy. Third is the period of pathology, in which the emphasis is on the detection and identification of the disease process. Again, in parallel, Caldwell took the whole course in medicine. The fourth, the period

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to today, is concerned with function, for this, no doubt, is the Age of Physiology and Chemistry in medicine. We might predict that the next period will be a mathematical one; actually, there are many indications that it is already with us in full strength. It should be pointed out that there are no barriers between these five stages—they all overlap. Certainly, physiology was not completely neglected during the first period—it is simply that the emphasis was anatomical. Furthermore, technical investigation, anatomical studies, pathological interpretation, all are continued even though physiology is now being emphasized. And critical measurements have been used from the very beginning.

That pathological anatomy should have been most important in the growth of roentgen diagnosis is easily understood; for the roentgenogram may picture abnormalities so vividly that it becomes virtually an "autopsia *in vivo*." For this reason, perhaps, the place of physiology in roentgen diagnosis has been neglected.

There were many efforts at physiological interpretation of the roentgenogram, even in the very first years of the development of the specialty. Cinematography was invented shortly after the discovery of the roentgen rays, and energetic, imaginative individuals attempted to combine the two methods as early as 1897. These pioneer efforts, as well as the early attempts at rapid film roentgenography, have come to their fruition in the past few decades. With the increasing use of contrast media, function has become a most important feature of roentgen diagnosis.

The usefulness of roentgen examination in the study of physiology was first stressed by the early experiments of Cannon on cats, using bismuth in the gastrointestinal tract. And such studies have continued. I would remind you of the extensive investigations into the roentgen interpretation of functional abnormalities of the gastrointestinal tract by many radiologists, perhaps best exemplified in recent years by the contributions of Ross Golden.[4] I can best express this concept by quoting from another Caldwell Lecturer, Doctor Harry Bockus:[1] "The X-ray examination offers the only consistently reproducible technic for the study of the motor activity of the digestive tract." The advent of cholecystography, intravenous urography and, more recently, intravenous cholangiography, in which the excretory and secretory functions of various organs are used for opacification, has brought home even more keenly the relationship of function to roentgen diagnosis.

For several decades, we have attempted to demonstrate the normal and pathological physiology of various organs, first by fluoroscopy, and then by numerous and elaborate mechanisms such as roentgen kymography, electrokymography, angiocardiography, cinefluorography, cardiac catheterization and, more recently, by isotope labeling. There is, however, a limit to how much we can afford in the elaboration of diagnostic procedures. I am thinking not only of the expenditure of money but, more importantly, of the consumption of personnel and of the cost in radiation exposure. We must, therefore, take the fullest advantage of the least amount of fluoroscopy, of the minimum number of roentgenograms and derive from them as much information as possible, both pathologic and physiologic.

The conventional roentgenogram presents an anatomical, a static image. Can this be converted into a moving, functional one without actually photographing the motion? I believe this is possible within certain limits. Just as we translate the roentgen photographic image into an anatomical one by our knowledge of living anatomy and the physical factors affecting the roentgenogram, so may we translate a static image into a dynamic one by proper interpretation. To do this, requires a solid background of knowledge, but one must also dare to reach out into the realms of the imagination. In the discipline of physiology particularly, images are easily conjured up. I would emphasize that these images are not mirages; to the untutored eye, they

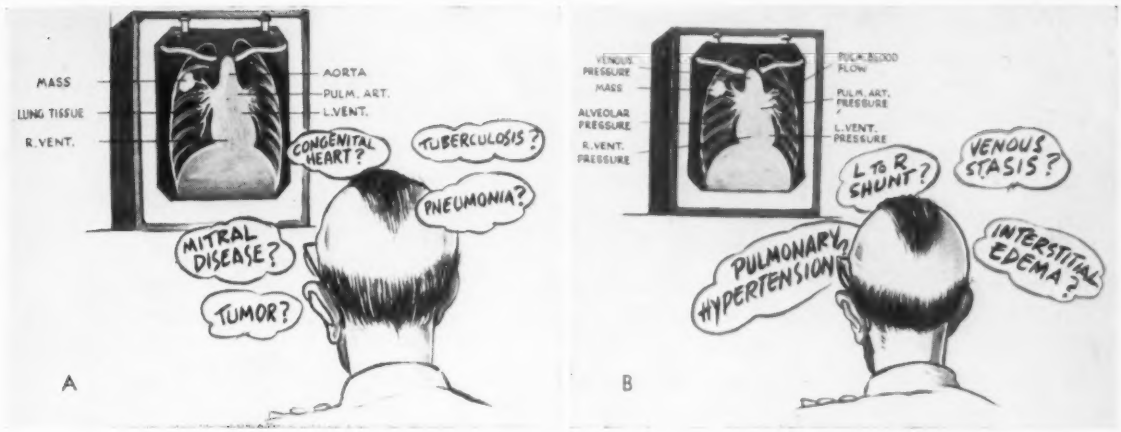

Fig. 1. (*A*) Conventional interpretation. The anatomical and pathological findings are observed. (*B*) Addition of physiological interpretation.

may seem so, but to the educated, the seeing eye, they are very real.

There are risks in the free use of the imagination, and caution must certainly be prescribed. I am certain too, that some of the physiological conclusions drawn from the roentgenogram may be the result of viewing in the retrospectoscope.[6] I am aware also of the skepticism with which the free translation of roentgen shadows into terms of anatomy, pathology and now physiology is often regarded. But the rewards of such interpretation far outweigh the dangers of this type of thinking. I would urge more thoughtful consideration of what we can observe in the simple roentgenogram. Often thinking about a case, studying the images, may make unnecessary more elaborate procedures. Perhaps I may be permitted to paraphrase the words of an illustrious playwright, "There is nothing on this earth that we see or know but thinking makes it so."

The addition to our thinking which I should like to stress is well illustrated by the striking changes in the character of the radiological teaching courses, such as we find at this very meeting, in which there are so many references to normal and abnormal physiology, especially of the respiratory, cardiovascular and osseous systems. More and more radiologists are thinking in such terms as mineral metabolism, kidney function and parathyroid secretion. We know that a careful assessment of the roentgen findings in many skeletal abnormalities, with some knowledge of the chemistry, will help to establish, with a high degree of accuracy, the nature of the pathological physiology which is present and, therefore, of the specific disease process.

My major discussion in this presentation lies in the realm of respiratory and circulatory physiology. The difference in thinking, here again, may well be illustrated by two cartoons. In Figure 1*A*, the radiologist is viewing the roentgenogram of the chest, thinking in conventional terms; he names the various structures and attempts to label the disease process which is present. In Figure 1*B*, he adds to this terminology—and I would emphasize that this is an addition, not a substitution—many expressions such as flow, pressure, shunt, etc., all of which imply motion and function.

We owe a great debt to the original roentgen studies of the physiology of the respiratory and vascular systems in the early twenties by Hugo Laurell of Upsala, with whom I had the good fortune to study. I, personally, owe a great debt to my friend, Nils Westermark, who carried on Laurell's tradition and proposed many of the ideas which I wish to consider tonight. It may be significant that, in many of the Scandinavian Departments of Radiology today, there

is a division of physiological investigation.

In the areas of abnormality of the respiratory and circulatory systems, there have been many contributions in the past few decades in which functional roentgen diagnosis is stressed. In the vast majority, the findings have been derived from contrast studies or by other complex methods. Such procedures as cardiac catheterization, contrast angiocardiography, cinefluorography, and rapid film roentgenography have been and still are of the greatest importance. From the pioneer contributions of many investigators, too numerous to name, have come enormous accretions to our knowledge. In fact, it is only through the study of such procedures and their results that we have learned the proper interpretation of the conventional roentgenogram of the chest. I have no wish to deprecate or depreciate such procedures. In many cases, they are the only means by which an accurate diagnosis can be made. I ask only that we exhaust the potential of the simplest procedure before undertaking a more complex one.

More recently there have appeared many studies in which the static natural contrast images of the heart, vessels and lungs have been used in the elucidation of functional roentgen diagnosis. The pioneer contribution of Wasson[7] in 1938 was of great importance in laying the groundwork for much of our knowledge in this field. I am also mindful of the more recent paper by Barden and Comroe on the roentgen representation of pulmonary physiology. I would quote one of the many significant passages from that paper, "Static shadows recorded on roentgenograms should be interpreted in terms of the functional changes which they imply." I am also deeply indebted to the monograph by Comroe and his associates[3] which illuminates in graphic form many of the questions which trouble radiologists.

The brilliant studies of the vascular changes in mitral disease which have been made by Kerley and his many British colleagues are now well known. In the April, 1958 issue of the *British Journal of Radiology*, in a series of papers on pulmonary hypertension, such interpretation is splendidly exhibited. And in the August, 1958 issue of this Journal, there is a series of papers which give similar attention to the manifestations of abnormal physiology exemplified by changes in the pulmonary vessels. Other investigators who have contributed substantially in this field are not listed because of limitations of space.

Some of the factors in the dynamics of the thorax which must be considered in the interpretation of roentgenograms of the chest are shown in Table 1. It is apparent that I have arbitrarily oversimplified the physiology; a detailed discussion would re-

Table I

Factors in the Dynamics of the Cardiorespiratory System

Pulmonary Ventilation		
General		Local
	Inflow—Outflow	
Intrathoracic Pressure		
Alveolar		Pleural
	Elevated—Depressed	
Venous Return to Heart		
	Increased—Decreased	
Pulmonary Arterial Blood Flow		
General		Local
	Increased—Decreased—Diverted	
Pulmonary Venous Blood Flow		
General		Local
	Increased—Decreased—Diverted	
Pulmonary Capillary Blood Flow		
Pulmonary Lymphatic Drainage		
Blood Pressure		
Vascular		Intracardiac
Pulmonary		
Peripheral		
	Elevated—Depressed	
Shunts		
Pulmonary		Peripheral
Intracardiac		Extracardiac

TABLE II

ROENTGEN FINDINGS IN THE HEART AND LUNGS WHICH MUST BE OBSERVED FOR PHYSIOLOGICAL INTERPRETATION

Lung Fields
Density
Increased—Decreased

Pulmonary Arteries
Central Peripheral
Size—Visibility—Pulsation

Pulmonary Veins
General Local
Size—Visibility

Pulmonary Lymphatics

Aorta
Size—Pulsation

Heart
Individual Chambers
Size—Contour—Pulsation

Mediastinal Structures
Position

Diaphragms
Position—Movement

quire a monograph. In Table II are listed the roentgen findings which should be observed in order to interpret the pathological physiology of the thoracic structures. Again it must be emphasized that the abnormalities which produce changes are often far more complex than appears here. Furthermore, various combinations of pulmonary and vascular abnormalities may further cloud the picture.

In addition to the conventional fluoroscopic and roentgenographic studies of the chest which are commonly made, it should be emphasized that roentgenograms in inspiration and expiration as well as those in inspiration with the Valsalva and Müller maneuvers must, in many cases, be undertaken. Laminagraphy is often valuable to make the pulmonary vessels more visible. By this procedure it is often possible to demonstrate venous and arterial abnormalities such as anomalous pulmonary venous drainage and arteriovenous fistulae. The combination of laminagraphy with changes in alveolar pressure may permit identification of the vascular nature of a mass in the lung without the use of contrast.

For purposes of demonstration, in some cases we have used the electronic method of reproduction, which occasionally serves to bring out more vividly the vessels of the lungs and other details. The peculiar character of some of the illustrations is thus explained.

Schematic drawings have also been prepared which simulate the roentgenogram but permit the delineation of pressure and flow factors. In these drawings the direction and size of the arrows indicate the direction and amount of flow of air in the lungs and blood in the circulatory system. The vertical line extending above the horizontal is a schematic representation of the pressure either in the alveoli or in the various portions of the cardiovascular system.

The cases described here are all familiar and are being presented purely as illustrations of how dynamic processes may be interpreted from the static roentgenogram. It should be emphasized again that the factors detailed in Tables I and II must be considered.

The simplest demonstration of the physiology of the lungs and heart is exhibited in roentgenograms of a normal individual made at the end of ordinary inspiration and expiration. The vessels of the lungs are about the same size in both phases but the lung fields are definitely denser in expiration. This is the result of the crowding together of the lung tissue and the loss of air so that the amount of blood is greater in proportion to the amount of air than during inspiration. There is no absolute increase in the amount of blood present within the lungs, but the absence of air makes the vessels less visible than during the inspiratory phase. The heart appears large in expiration only because it has changed its shape rather than because there

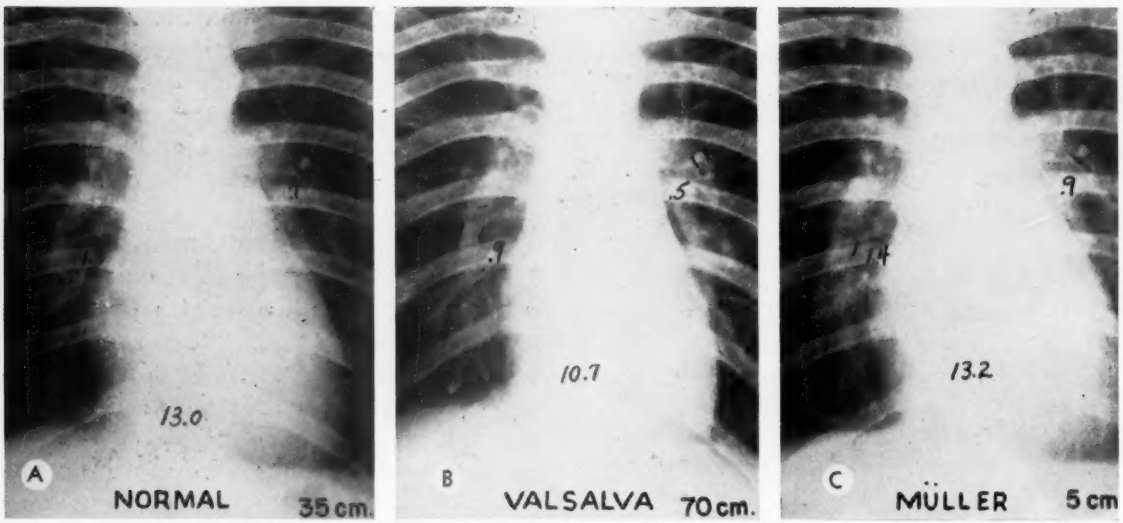

FIG. 2. Effects of changes in alveolar pressure in a normal young adult. Posteroanterior roentgenograms all made at end of a deep inspiration. (*A*) Normal pressure (35 cm. H_2O). Note size of heart and pulmonary arteries. (*B*) High alveolar pressure (70 cm. H_2O) (Valsalva maneuver). The heart and major pulmonary vessels have decreased sharply in size. (*C*) Low alveolar pressure (5 cm. H_2O) (Müller maneuver). The heart and pulmonary arteries have increased in size far above that shown in *B* and are slightly larger than with normal pressure as shown in *A*.

is any true change in size. If, however, inspiration is accompanied by a marked rise in intra-alveolar pressure as occurs with the Valsalva maneuver, striking changes may be observed. Such roentgenograms are made with the glottis closed and the intrapharyngeal pressure increased by blowing. A marked decrease in alveolar pressure can be obtained by the Müller maneuver which is also accomplished in inspiration with the glottis closed but with a further effort at inspiration, that is, by sucking. The differences in appearance may be striking as illustrated in Figure 2.

Three posteroanterior roentgenograms of the chest of a normal young adult were made in rapid succession with varying pressures as measured with a manometer connected with the pharynx as described by Westermark.[8] In the first (Fig. 2*A*), the pressure was normal (35 cm. H_2O). In the second (Fig. 2*B*), the pressure was elevated (70 cm. H_2O) and the heart and pulmonary vessels decreased sharply in size. In the third (Fig. 2*C*), the pressure was reduced to 5 cm. H_2O and the heart and arteries became much larger, even somewhat larger than during normal inspiration. As shown in the drawing (Fig. 3), the reduction in cardiac size when there is increased intra-alveolar pressure results from compression of the venae cavae. This prevents the free return of blood to the heart which, in turn, fails to fill properly. There is also seen a diminution in the size of the pulmonary arteries since the cardiac output under such circumstances is greatly decreased. During the low pressure phase (Fig. 2*C* and 3*B*), the heart and pulmonary vessels increase in size because the return flow of blood to the heart and thence to the lungs is greatly accelerated. During the course of ordinary chest roentgenography, especially in young children, the patient may unconsciously close the glottis and exert pressure during what he thinks to be a deep inspiration. As a result, marked changes in cardiac size from one roentgenogram to another are occasionally found. Since few of us have adopted the recommendation of Westermark to make roentgenograms routinely at a constant pressure by measuring with a manometer at the time of exposure, such accidental increases in alveolar pressure

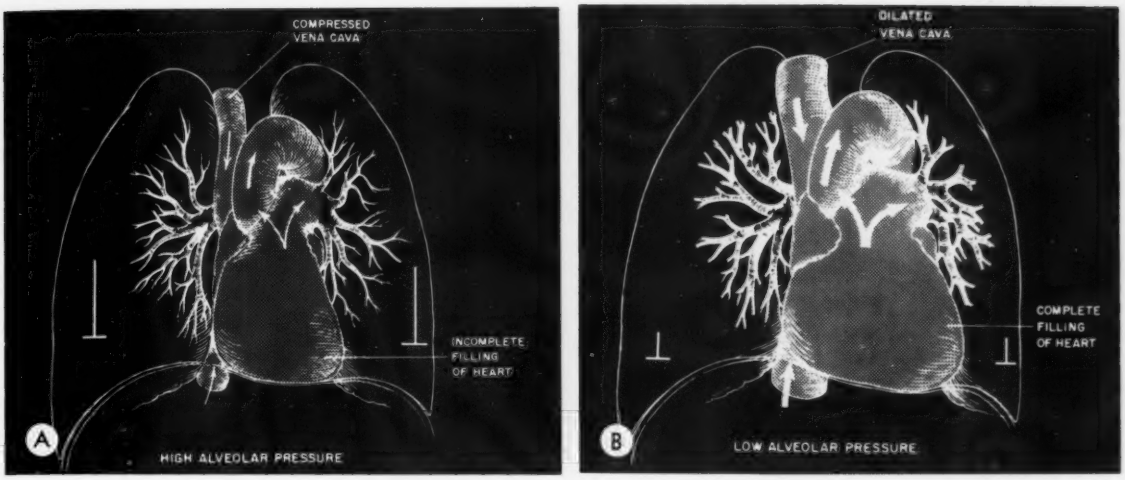

Fig. 3. Diagrams to illustrate the effects of high and low alveolar pressure. (*A*) High pressure, indicated by the inverted T overlying the lungs, diminishes the return flow of blood from the venae cavae so that the heart is poorly filled and small. The output into both the pulmonary arteries and the aorta is diminished and they are decreased in size. (*B*) Low alveolar pressure causes a marked increase in flow of blood to the heart, which is now greatly increased in size and there is a greater output into the pulmonary arteries and aorta.

may go unnoticed and misinterpretation of the changes in heart size result. A study of the roentgenograms shown in Figure 2, *A*, *B* and *C* as well as of the diagram in Figure 3, *A* and *B* indicates that careful examination of the size of the pulmonary vessels, the size of the heart, and the clarity of the lung fields has permitted us to interpret alveolar pressures, pulmonary blood flow and venous return to the heart, all of which are dynamic responses of the cardiorespiratory organs.

We have studied the pulmonary circulation under both normal and abnormal conditions using extreme degrees of the Valsalva and Müller maneuvers in order to change the intra-alveolar pressure. With increased pressure, the pulmonary arteries diminish as much as 50 per cent in size as compared to a normal inspiratory phase. An increase in the size of the pulmonary vessels occurs when the alveolar pressure is diminished below the normal, although the difference is less. In the case of pulmonary hypertension, whether primary or the result of a left to right shunt, as demonstrated in Figure 4, *A* and *B*, such changes do not occur. In this case, there is an interventricular septal defect and the pulmonary artery pressure is elevated. Under such circumstances, the vessels become more rigid and changes in intra-alveolar pressure do not produce much effect. The heart itself, however, is still affected to some degree since the venous return is impeded regardless of the pulmonary vascular pressures. In the case of pulmonary stenosis (Fig. 5, *A* and *B*), changes in alveolar pressure will produce little change in the size of the branch arteries although there may be a marked change in the size of the heart and even of the major pulmonary artery. In this case, the amount of blood coming from the heart to the pulmonary arteries is impeded to such a degree that there is an increase of pressure in the right ventricle and a minimal flow. Even though the pulmonary intra-alveolar pressure is increased, the amount of pulmonary blood flow can scarcely be diminished below what has already been present, and, therefore, there is little or no change in the size of the vascular shadows.

The fact that vessels change greatly in size with change in alveolar pressure, while solid infiltrates do not, can be used as a diagnostic sign of vascular anomalies of the lung. The procedure is well illustrated in

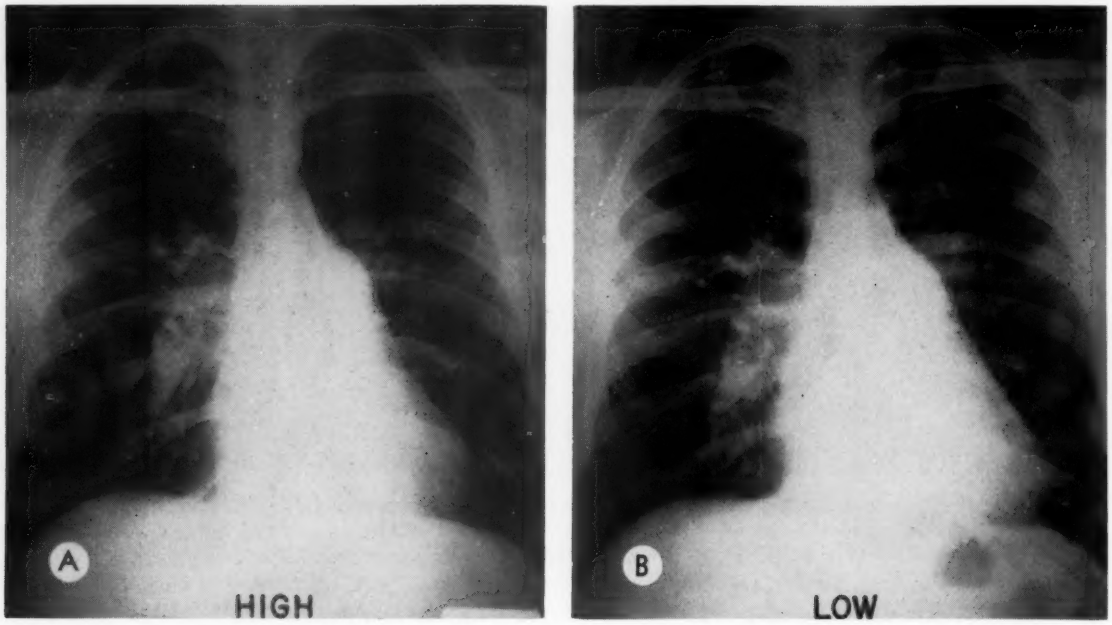

Fig. 4. Pulmonary hypertension from interventricular septal defect. (*A*) Increased alveolar pressure (Valsalva maneuver). The pulmonary arteries do not diminish in size because of their rigidity. The heart is moderately reduced in size. (*B*) With decreased intra-alveolar pressure, very little change in the size of the vessels and only a minor increase in the size of the heart can be observed. Note the markedly diminished circulation to the periphery of the lungs, which is the result of the pulmonary hypertension.

Figure 6, *A* and *B*. Laminagrams were made with high pressure (Fig 6*A*) and with low pressure (Fig. 6*B*). The marked increase in the size of the shadows with low pressure indicates clearly the nature of the lesion, a pulmonary arteriovenous fistula. We have utilized this sign most effectively on many occasions for the diagnosis of this condition.

A somewhat similar physiological situa-

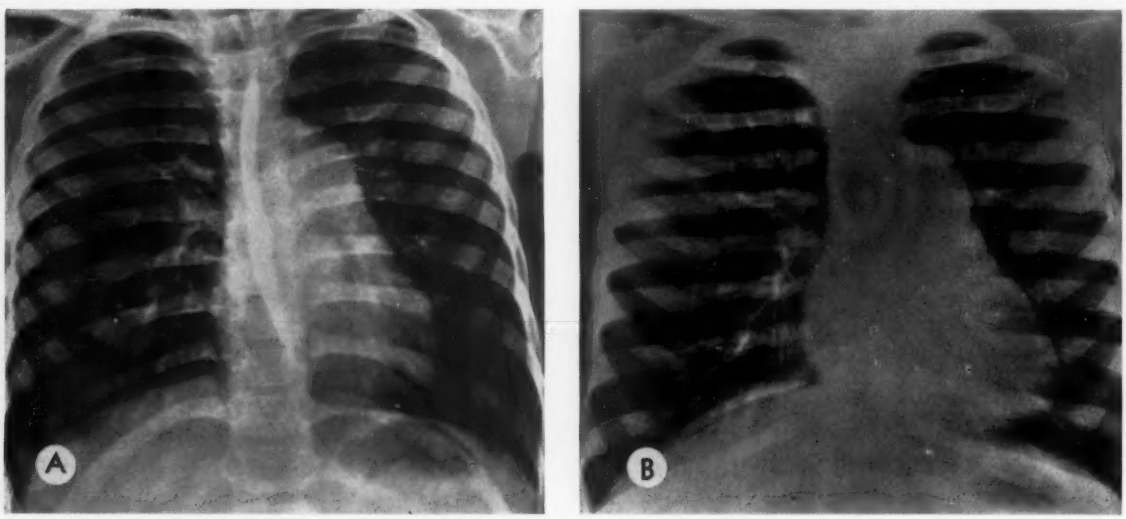

Fig. 5. The effects of changes in intra-alveolar pressure in a patient with pulmonic stenosis. (*A*) Increased intra-alveolar pressure. The heart is small but the pulmonary trunk is greatly enlarged and the pulmonary arteries do not change in size. (*B*) Decreased intra-alveolar pressure. There is some increase in the size of the heart but the pulmonary vessels remain about the same.

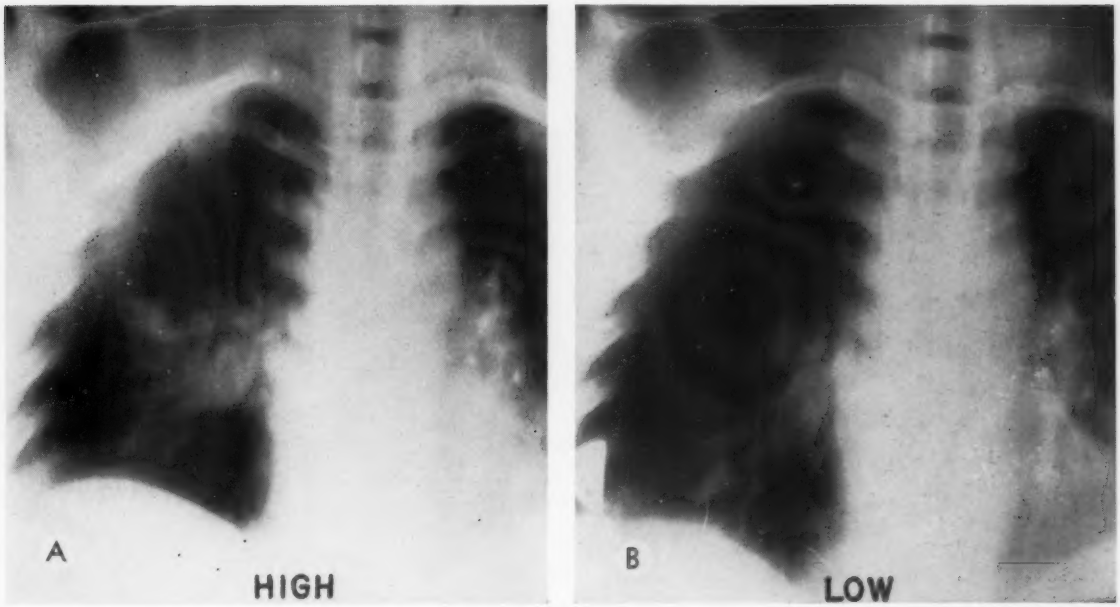

Fig. 6. Arteriovenous fistula of right lung. (*A*) Laminagram with high intra-alveolar pressure. Note size of vessels in the mass. (*B*) Low pressure produces a marked increase in the size of the shadows, indicating the vascular nature of the process.

tion is present during the course of status asthmaticus as demonstrated in Figure 7, *A* and *B*. The roentgenogram of the chest before the onset of a prolonged acute asthmatic attack is shown in Figure 7*A*. Note the size of the heart, thymus and the pulmonary vessels. Figure 7*B* shows the striking diminution in the size of the heart, the increased clarity of the lung fields and the diminution in the size of the vessels during the course of a prolonged attack of status asthmaticus in which the patient had

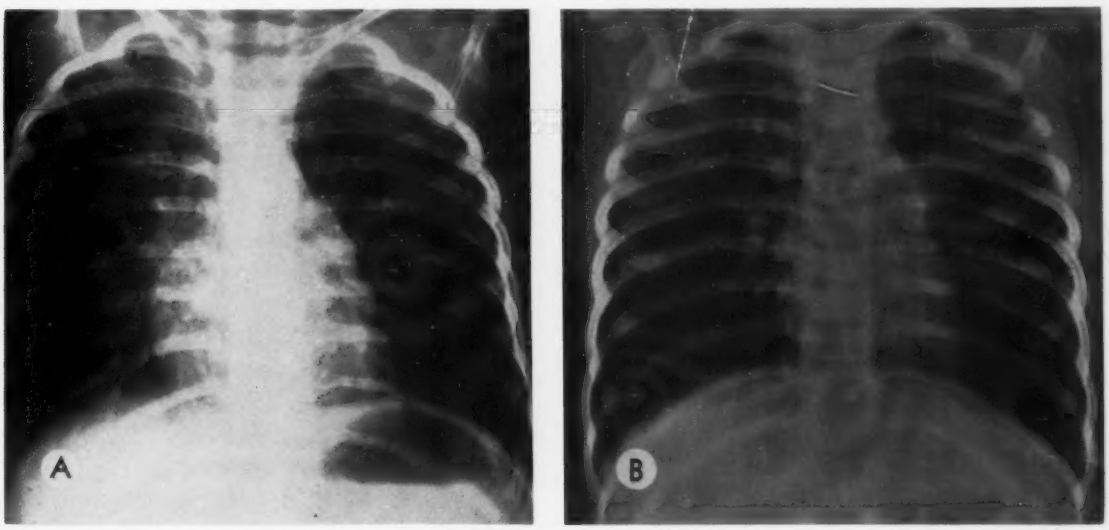

Fig. 7. Effect of status asthmaticus. (*A*) Child with bronchial asthma during ordinary course of intermittent attacks. Note size of heart and pulmonary blood vessels. (*B*) Same child during attack of status asthmaticus. There is a sustained reduction in the size of the heart because of the increased intra-alveolar pressure. The pulmonary vessels are likewise reduced in size. After relief of the attack, the appearance of the heart and lungs returned to that seen in *A*, the heart area increasing over 50 per cent.

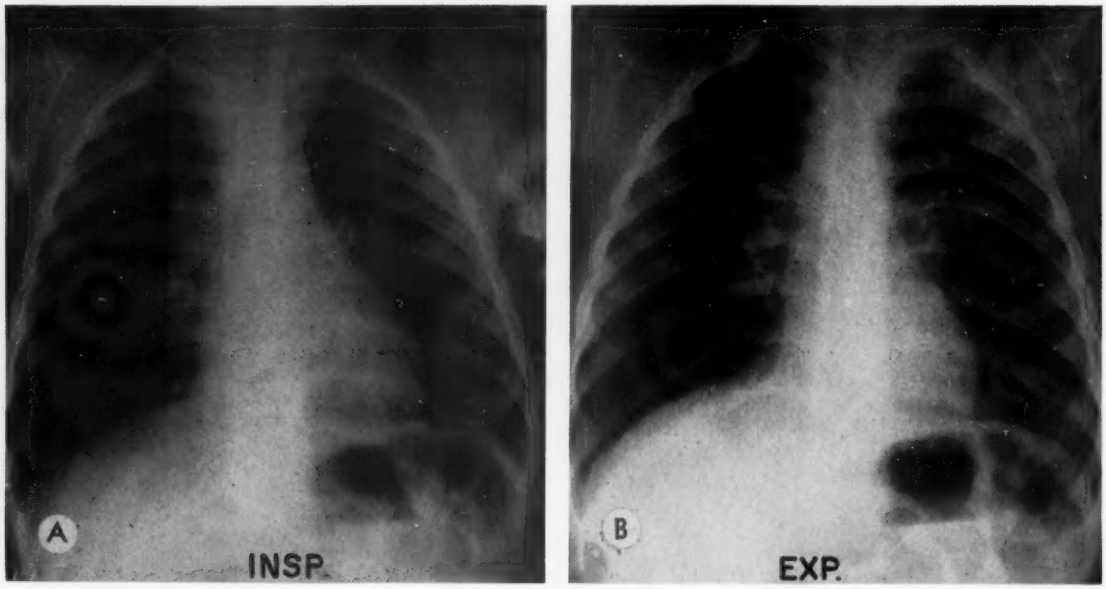

Fig. 8. Partial obstruction of trachea from foreign body. (*A*) Roentgenogram taken during inspiration. Note size of heart and pulmonary vessels. (*B*) Roentgenogram taken during expiration. A paradoxical change in the size of the heart and pulmonary vessels has occurred. Both are diminished rather than increased in size as a result of the increased intra-alveolar pressure.

great difficulty with expiration. The strenuous expiratory efforts produced, in effect, a Valsalva maneuver. The findings are similar to those illustrated in Figures 2*B* and 3*A* although the site of obstruction was peripheral. When this patient recovered from the attack, the size of the heart and the pulmonary vessels were restored to their pre-attack state.

A similar phenomenon occurs when there is partial obstruction of the trachea from a foreign body as shown in Figure 8, *A* and *B*. Here, it is necessary to know in what phase of respiration the roentgenogram is made. Figure 8*A* was made in inspiration and 8*B* in expiration. The change in the size of the heart is reversed from that which is seen during normal respiration. Likewise, the pulmonary vessels appear smaller and the lungs somewhat clearer during expiration rather than during inspiration, a reversal of the normal state. The diaphragms have moved very little between the two phases. The reason for the changes is that the patient is unable to expire properly, the lungs remaining almost constantly in a state of inspiration. The diagrams in Figure 9, *A* and *B* indicate the mechanics of the situation. A foreign body is partially obstructing the trachea and permits moderate inspiration of air, but with the smaller diameter of the trachea during expiration, the foreign body produces complete obstruction. As a result, the great effort at expiration produces a sharp increase in the alveolar pressure; the return flow of blood to the heart is impeded and the output of blood to the pulmonary vessels decreases.

In the case of bronchial obstruction, a somewhat similar phenomenon takes place except that only one lung or one lobe is involved, with resultant sharp differences in the density of the two sides. While such findings have been described repeatedly, it may be worthwhile to point out the marked differences which exist in the size of the pulmonary vessels on the two sides and in the relative amounts of blood which may be present in the normal portions of the lung, as compared to the obstructed portion, during the phase of expiration. As shown in Figure 10*A*, during inspiration there is only a slight difference in the radiability of the middle and lower lobes on the

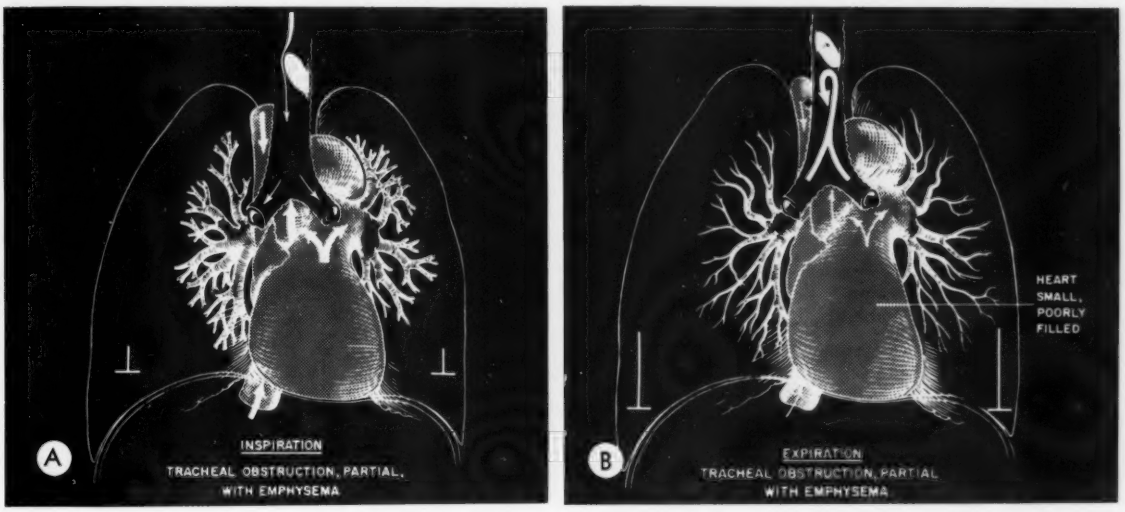

Fig. 9. Diagrams illustrating the effects of tracheal foreign body. (*A*) Inspiration. Relatively low intra-alveolar pressure results from partial obstruction of the trachea. This produces an increased return flow of blood to the heart with increased size. The vessels are larger because of the increased output. (*B*) Expiration. The foreign body occludes the trachea completely. With the expiratory effort, the intra-alveolar pressure is elevated and the return flow of blood to the heart is diminished. The heart is small and the output is decreased.

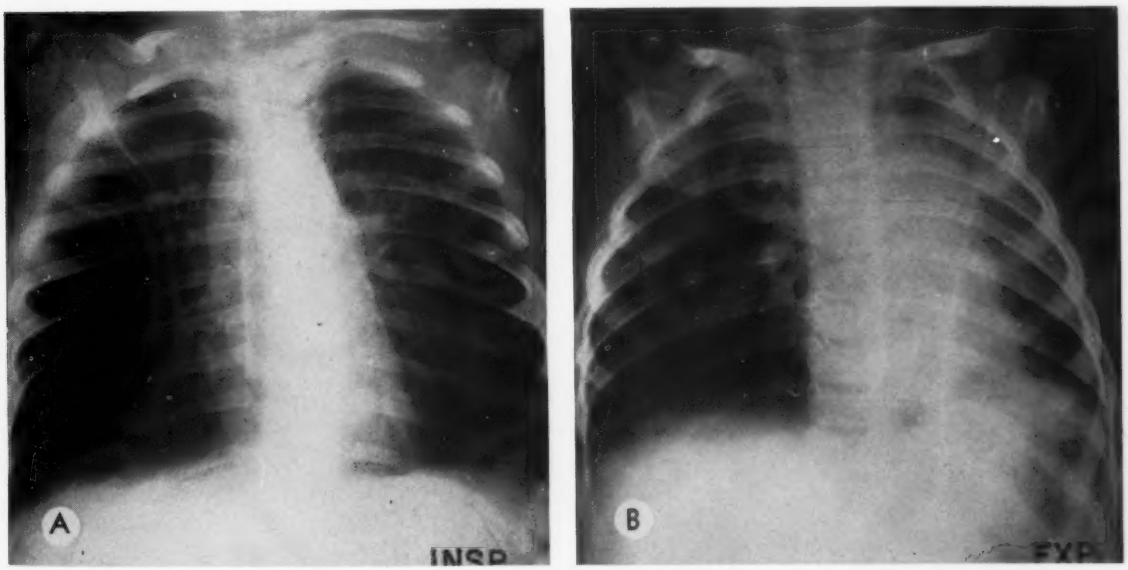

Fig. 10. Foreign body in the right stem bronchus. (*A*) Roentgenogram in inspiration. Both lungs appear approximately equal in size and density but there is a slight decrease in vascular marking in the right middle and lower lobes. (*B*) Roentgenogram in expiration. The right middle and lower lobes remain expanded while the right upper lobe and the entire left lung have increased markedly in density and decreased markedly in size. The foreign body partially obstructs the bronchus to the right middle and lower lobes so that they are unable to expire. With the effort at expiration, the alveolar pressure is increased, the lobes expand and the circulation to these lobes is greatly diminished. The shunting of circulation to the normal portions of the lungs during the expiratory phase simulates the appearance of pathology.

right side as compared with the right upper lobe and the entire left lung. The pulmonary vessels in the right upper lobe and on the left side are more visible than in the middle and lower lobes. On expiration, however (Fig. 10*B*), a marked difference can be seen. The heart is displaced sharply to the left side, the left diaphragm rises, and the left lung is greatly increased in density. Even more striking is the marked increase in the density of the right upper lobe and its small size. The right middle and lower lobes, unable to expire because the foreign body in the stem bronchus produces a complete obstruction during expiration, show a marked relative expansion. In fact, there has been no diminution in their size from inspiration to expiration, while the right upper lobe and the left lung have expired their air. As a result of the marked increase in intra-alveolar pressure which has now occurred in the middle and lower lobes, there is a marked diversion of the circulation from these portions of the lung to the normal portions. With more blood, there is a greater than normal density. An unwary observer, not realizing that Figure 10*B* was made in expiration, could readily conclude that the patient had pneumonia of the right upper lobe or of the left lung, and that the only normal portions were the right middle and lower lobes. Again, a study of the pulmonary vessels, the radiability of the lungs and the position of the heart and diaphragms in the two phases of respiration reveals adequately the pathological physiology of the respiratory tract and the secondary changes in the circulation which result.

The effect of obstructions of the bronchus and the rapid change which may occur from emphysema to atelectasis is excellently demonstrated by the case shown in Figure 11, *A* and *B*, a sixteen year old girl who had a routine roentgenogram of the chest made. There was observed on the conventional roentgenogram taken in inspiration (Fig. 11*A*) a minimal increase in radiability of the left lung. Therefore, a roentgenogram was also taken in expira-

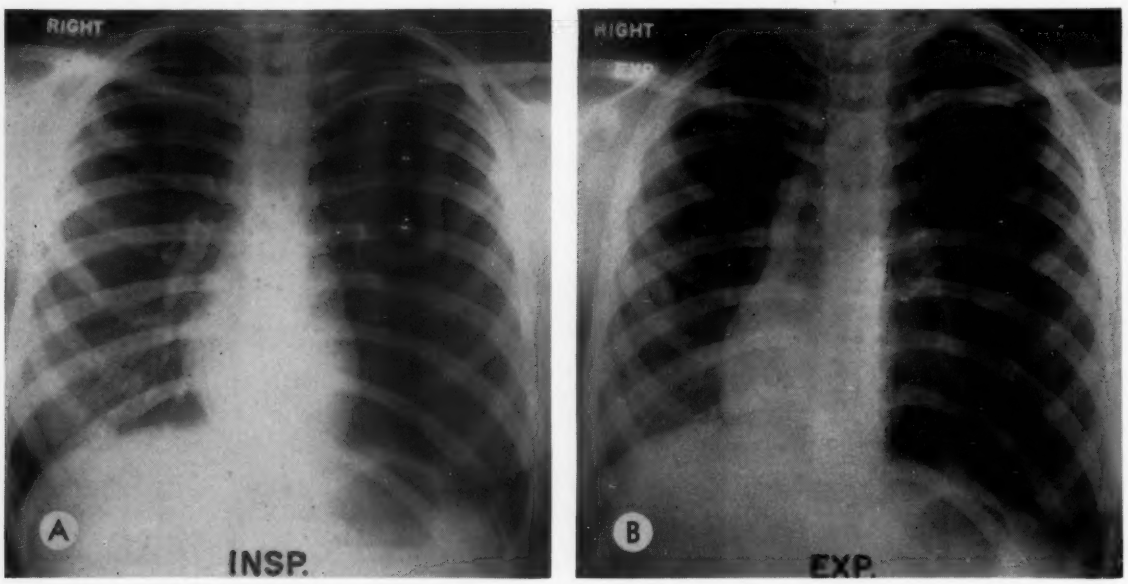

Fig. 11. Adenoma of left bronchus with partial obstruction. (*A*) Inspiration roentgenogram shows some emphysema of entire left lung. Note the diminished circulation to the left lung as the result of the increased intra-alveolar pressure. The circulation to the right lung is increased because of the diversion. The heart and mediastinum are displaced slightly to the right. (*B*) With expiration, these findings are greatly exaggerated. The right lung fails to expire, the diaphragm does not rise and the heart and mediastinum are displaced markedly to the right side. The diminished circulation on the left is again seen. The increased amount of blood on the right side is indicated by the increase in density of the right lung.

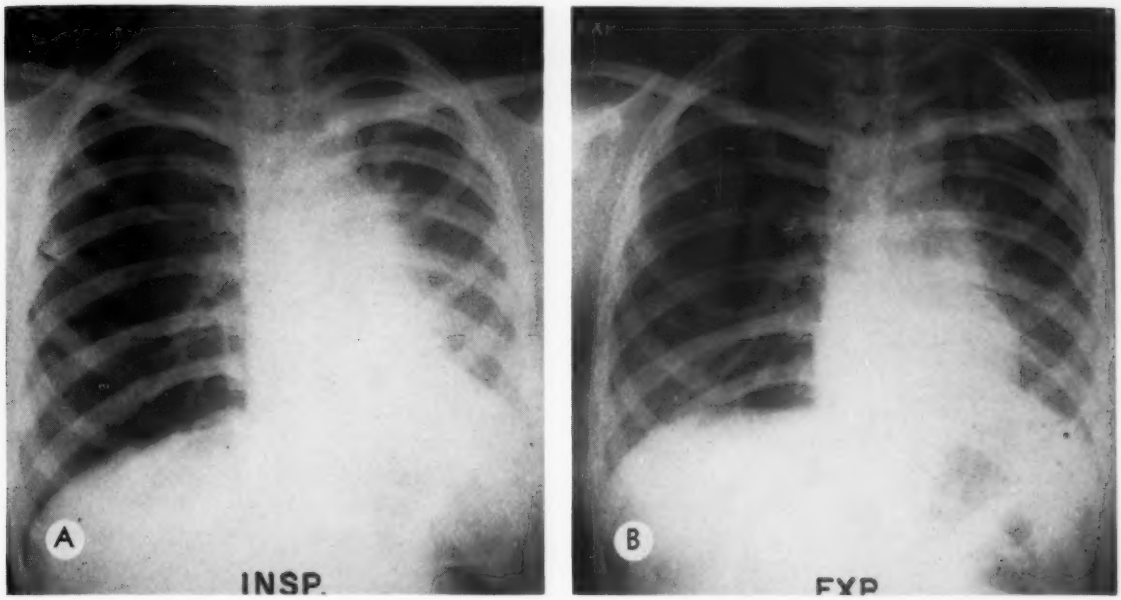

Fig. 12. Same case as in Figure 11, *A* and *B* following bronchoscopy. Edema, added to the tumor, has produced more complete obstruction. (*A*) Roentgenogram in inspiration. Increased density of left lung with displacement of mediastinum and diaphragm toward the side of the lesion is now apparent. The increased circulation to the right side is no longer present since there is now, if anything, some diversion of circulation to the obstructed lung which exhibits beginning atelectasis. (*B*) Expiration roentgenogram. The difference between the normal and abnormal lung is less apparent, exactly the opposite of the finding in obstructive emphysema.

tion (Fig. 11*B*). This latter exhibits an obstructive emphysema in the left lung. The heart is displaced to the right, the right diaphragm elevates in normal fashion, but the left has not changed its position. The right lung is greatly increased in density far beyond the usual expiratory excursion because of the diversion of circulation to this side. Because there was no history of foreign body, nor of any other incident which might produce this, a laminagram was taken and evidences suggesting a tumor in the left main bronchus were found. On bronchoscopy, an adenoma was observed; some trauma to the bronchus resulted. Within twenty-four hours, the changes observed in Figure 12, *A* and *B* were seen. At this time, the roentgenogram made during inspiration (Fig. 12*A*) shows that the left lung is increased in density as compared to the right; the difference is marked. Contrary to the findings in obstructive emphysema, the difference is diminished during expiration as shown in Figure 12*B*. Obviously, atelectasis of the left lung is supervening because the trauma to the bronchus has caused edema which, together with the foreign body, have produced a complete obstruction. As soon as the adenoma was removed, the lung regained its aeration. The brilliant fashion in which the pathological physiology of this condition can be observed through such simple studies is well demonstrated. A similar situation, of course, occurs with carcinoma of the lung and may be an extremely important sign of the lesion.[6]

The effects of varying pressures in the lungs and pleura are well illustrated in Figure 13, *A* and *B*, a case of pneumothorax on the right side in which the right lung is relatively normal with no adhesions. The elevated intrapleural pressure may produce a mediastinal hernia. If roentgenograms are made in inspiration (Fig. 13*A*), the hernia may not be clearly visible, since the pressure in the pleural cavity may be diminished by the inspiratory expansion of

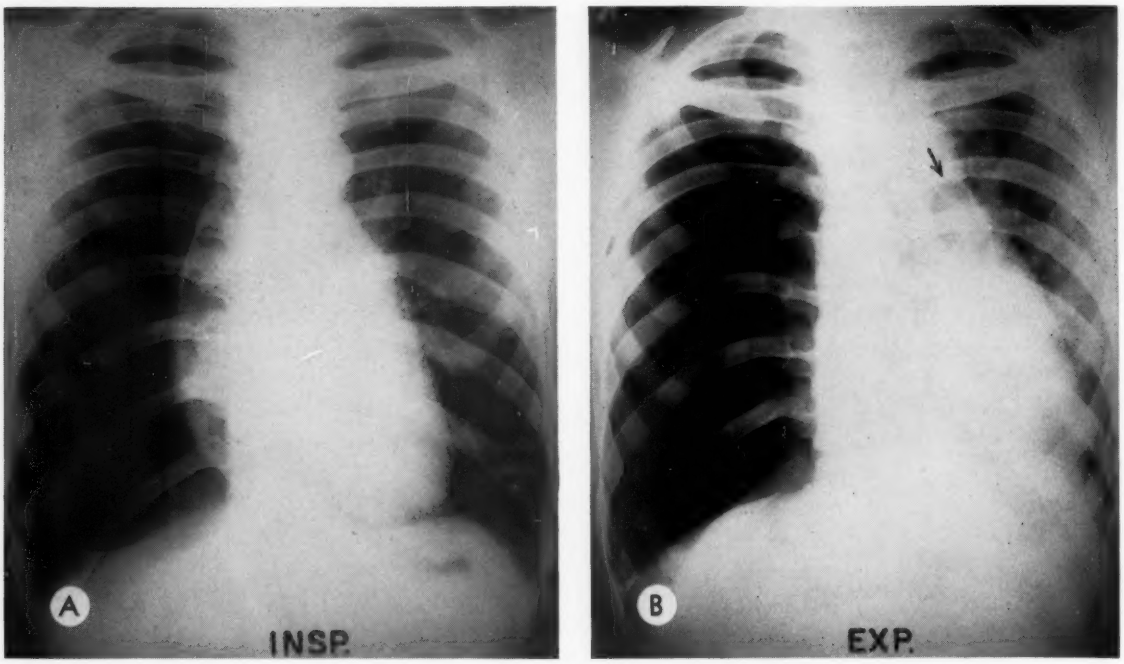

Fig. 13. Pneumothorax with marked collapse of the right lung. (*A*) Roentgenogram in inspiration shows little or no evidence of mediastinal hernia. There is, however, some evidence of diversion of the circulation to the left lung. (*B*) In expiration, the mediastinal hernia becomes apparent (arrow). The reduction in volume on the left side and the marked increase in pressure on the right, which cannot respond to the expiratory effort, cause the herniation to the opposite side.

the thorax and the difference in pressure on the two sides may be insufficient to produce a hernia even though the mediastinal structures are displaced to a moderate degree. During expiration, however, the volume on the normal side diminishes very greatly while on the abnormal side there is little or no change in volume. At the same time, because of the effort at expiration, the pressure on the pneumothorax side is greatly increased and, as a result, a characteristic herniation through the mediastinum can be seen (Fig. 13*B*). If however, prior to the development of the pneumothorax changes in the lung had been present, paradoxical herniation may result. This may be particularly apparent if there is emphysema or some other cause for increased intra-alveolar pressure on the contralateral side. Such a case is well illustrated in Figure 14, *A* and *B*, for here the herniation becomes more apparent during inspiration (Fig. 14*A*) and diminishes during expiration (Fig. 14*B*), but it is a hernia extending toward the side of the pneumothorax. In this case there was atelectasis of the right lung prior to the development of the pneumothorax so that the pressure on the right side was greatly diminished. The advent of the pneumothorax simply brought this closer to normal. The inspiratory roentgenogram (Fig. 14*A*) shows that the left lung is greatly distended and emphysematous so that its pressure is elevated. With expiration (Fig. 14*B*), the inability of the left lung to expire properly produces increased alveolar pressure and herniation to the contralateral side develops. Again, we see the vivid manner in which simple posteroanterior roentgenograms, made during both phases of respiration, exhibit the pathological physiology and the dynamics of the respiratory process.

One of the interesting physiological phenomena which often leads to some confusion in the interpretation of roentgenograms is the unilateral diversion of the pulmonary circulation when the pressure

on the two sides of the thorax becomes markedly unequal. This may be the result of a marked increase in the intrapleural pressure as in the case of an acute spontaneous pneumothorax shown in Figure 15*A*. There is a marked compression of the entire right lung. The increase in size of the left pulmonary arteries is striking and was even more apparent when compared with roentgenograms made after the pneumothorax had been absorbed and the right lung expanded. The drawing in Figure 15*B* illustrates the dynamics of this situation. With the great increase in pressure on the right side, the circulation to the right lung is cut off to a very large extent and correspondingly there is a sharp increase in blood flow into the left pulmonary vessels. Because of their ready distensibility, these vessels enlarge greatly under the influence of the increased flow and we see the picture of large pulmonary arteries. In times past this has been mistaken for abnormalities occurring in this lung when, in fact, it is perfectly normal.

A similar situation obtains in the case of a unilateral tension pneumatocele which is illustrated in Figure 16, *A* and *B*. In Figure 16*A* the large pneumatocele on the right and the exaggerated pulmonary arteries on the left side are clearly shown. This is the result of the diversion of circulation previously mentioned. To demonstrate this more effectively, a pulmonary angiogram was made (Fig. 16*B*). The almost complete absence of circulation on the right side and the very extensive dilated pulmonary arteries on the left are better seen. In the presence of emphysema of unilateral character, such as is the case with partial obstruction from a foreign body as shown in Figure 10, *A* and *B* or in any situation where there is unilateral increased intra-alveolar or intrapleural pressure, this type of circulatory diversion will occur.

It is interesting to observe that, in some

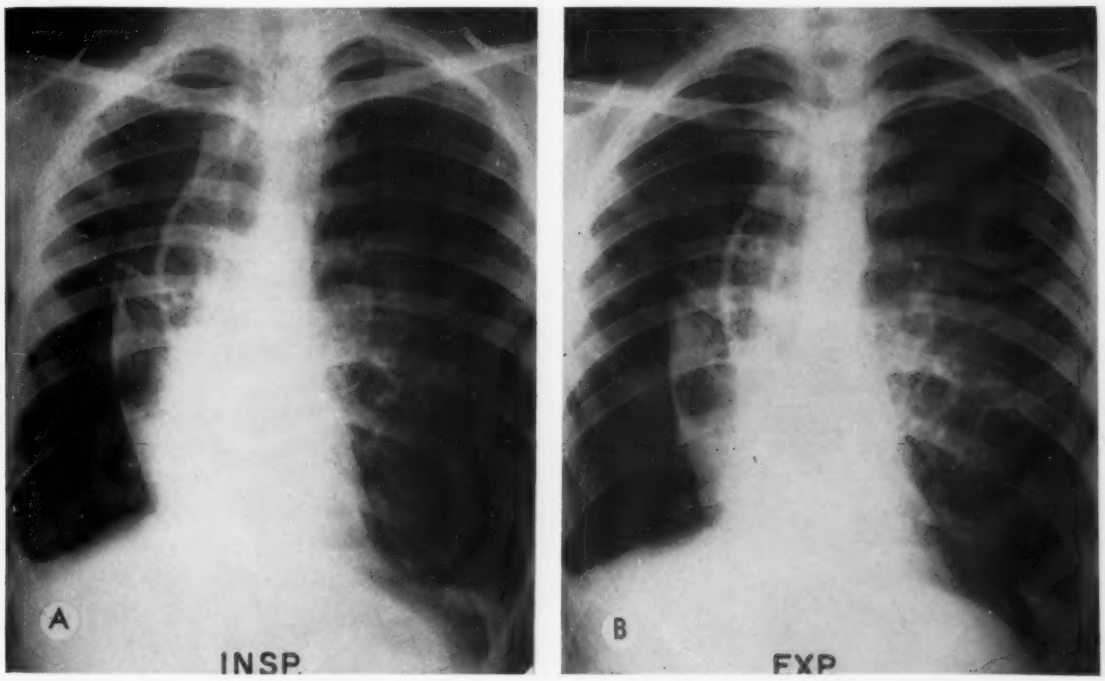

Fig. 14. Pneumothorax, right, with paradoxical mediastinal hernia. (*A*) Inspiratory roentgenogram. The left lung is emphysematous. The right lung was atelectatic before onset of pneumothorax. This together with adhesions produces a fixation of the right side and a lower pressure. As a result, the hernia extends to the pneumothorax side rather than to the normal. (*B*) Roentgenogram in expiration. The hernia diminishes in size because of the differences in pressure which have been emphasized. The change in size is exactly opposite to that found in a conventional pneumothorax.

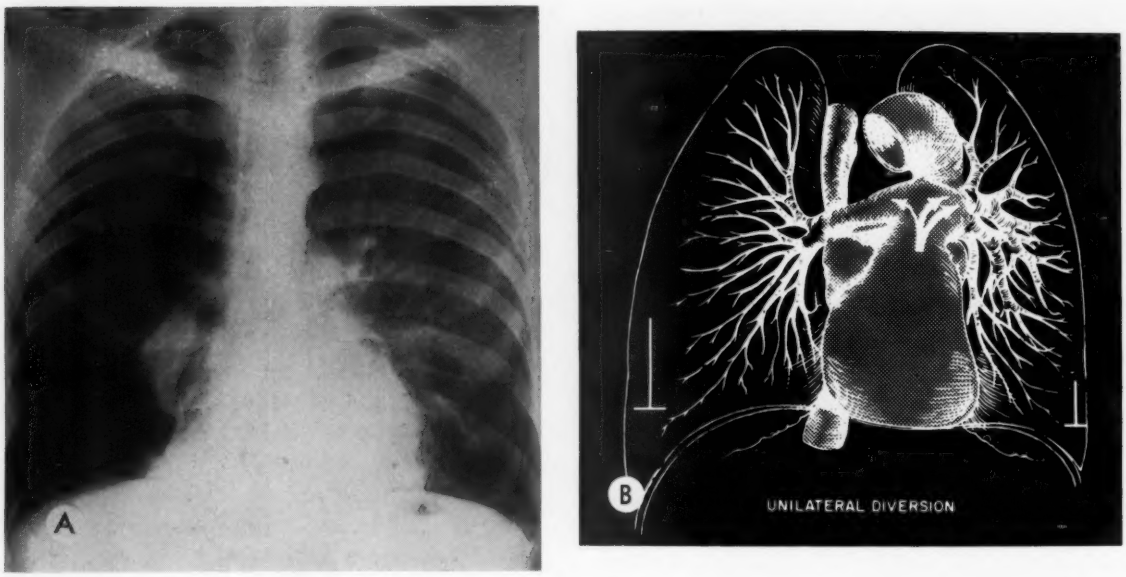

Fig. 15. Diversion of circulation to the normal lung from increased intra-alveolar or intrapleural pressure. (*A*) Spontaneous pneumothorax with marked collapse of the right lung. The intrapleural pressure is greatly increased on the right, producing compression of the vessels. Note the marked increase in the vascular shadows on the left resulting from the diversion of circulation to this side. (*B*) Diagram illustrating the same finding.

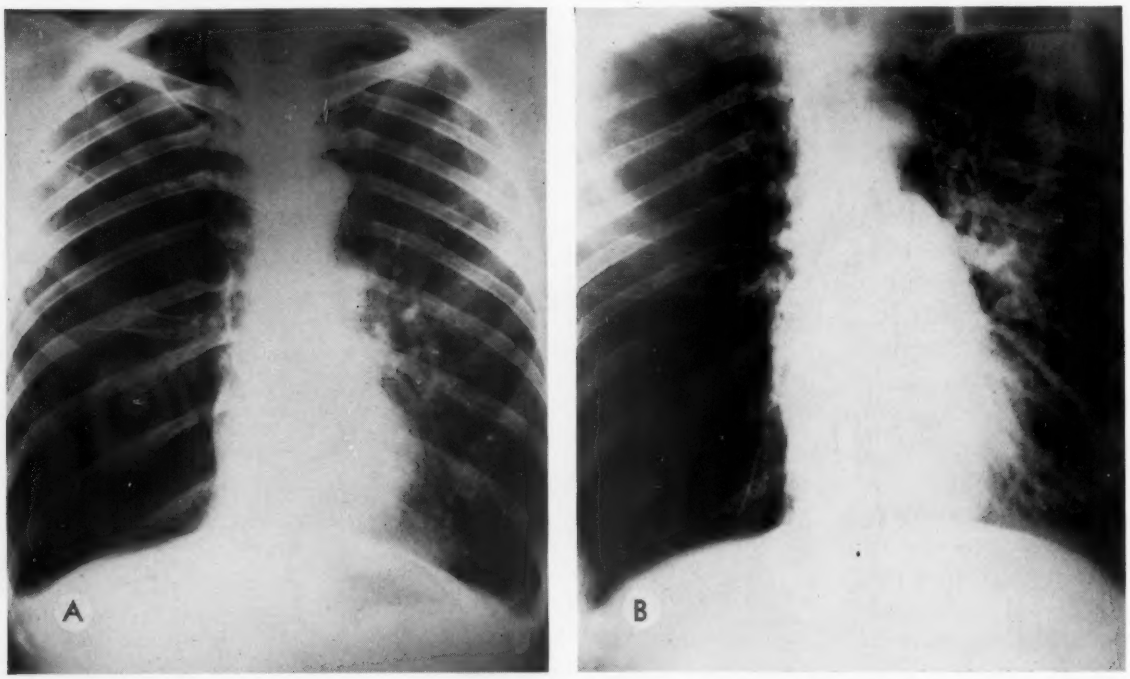

Fig. 16. Massive pneumatocele, right. (*A*) Simple roentgenogram showing almost complete absence of circulation on the right side because of the ectasia of the alveoli and the marked distention. On the left side, however, the arteries are greatly increased in size because of the diversion of circulation. (*B*) Pulmonary angiogram in the same case demonstrating vividly the increase in size of the left pulmonary arteries resulting from the diversion.

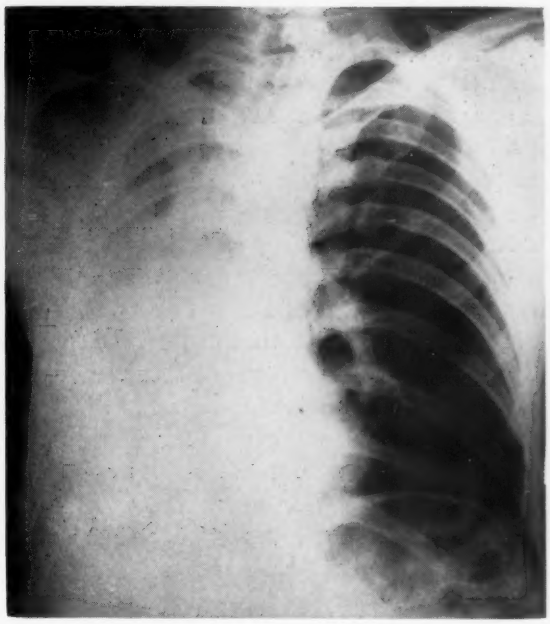

Fig. 17. Massive atelectasis of sudden onset. The right lung is almost completely atelectatic, yet there is little or no change in the circulation on the left side. This is characteristic of atelectasis in which there is a diminished intra-alveolar pressure on the abnormal side.

cases of massive atelectasis, the diversion of the circulation referred to above does not occur. This is well illustrated in Figure 17 in a case of massive atelectasis of the right lung occurring very rapidly as a result of morphine poisoning. It is notable that there is no increase in circulation in the left lung despite the practically complete collapse of the right lung. It is significant that the patient had distinctive cyanosis at this time. The explanation of this phenomenon is beautifully illustrated in the book by Comroe and his associates.[3] As long as there was no obstruction to the circulation extending into the right lung and yet no air came into that lung, the blood circulating through it was not oxygenated. A mixture of blood then came through the pulmonary artery containing the oxygenated blood from the left lung and the unoxygenated blood from the right lung, thus causing a minor degree of cyanosis. In almost all cases of pneumonia, obstruction to the circulation as well as to the intake of air occurs, and as a result cyanosis is rather uncommon. Also, in some cases of atelectasis, cyanosis is not present, probably because circulatory obstruction occurs along with the respiratory obstruction and the blood is diverted to the normal lung. The fact that one may see cases such as this, however, illustrates how important this matter of the diversion of circulation to the normal lung is in maintaining homeostasis.

In any consideration of the vascular pattern of the lungs, the distinction between arteries and veins must be understood. It is not always possible from simple roentgenograms of the chest to make this distinction when the vessels are normal. The differences in the course and distribution of the normal arteries and veins can at times aid in the differentiation. However, when there is an abnormality of the circulation, the distinction can be readily made, even in roentgenograms without artificial contrast, and every effort should be made to do so. The appearance of dilated pulmonary arteries, such as occurs in a left to right shunt with increased pulmonary blood flow, is indicated diagrammatically in Figure 18*A*. The arteries are relatively straight, sharply defined and stand out very clearly from the dry, air-filled lungs which form the background. Many of them will be seen in cross-section as rounded, homogeneous dense shadows. On the other hand, venous distention, resulting usually from stasis, gives a completely different picture (Fig. 18*B*). The veins are tortuous and poorly defined. With stasis there tends to be a transudation of fluid into the interstitial tissues and, of course, eventually into the alveoli of the lung. As a result, the contrast between the blood-filled veins and the surrounding tissues is greatly diminished. The lack of sharpness of the veins and their tortuous course make it difficult to demonstrate them clearly in the roentgenogram. At the same time it is this fact which helps to distinguish the veins from the arteries. The importance of this, of course, lies in the nature of the lesions which produce such appearances. With congenital defects,

especially those in which there is a left to right shunt, or during certain stages of pulmonary hypertension, the arteries are almost always greatly enlarged. Occasionally, as indicated above, as a result of a unilateral change in intra-alveolar pressure, a similar appearance will occur on one side. Left heart failure such as produced by mitral and aortic valvular disease, disease of the myocardium itself, as well as other heart lesions, leads to stasis in the lungs with consequent distention of the pulmonary veins and eventually pulmonary edema.

In any consideration of congenital heart disease, particularly the demonstration of enlargement of the pulmonary arteries is of the first importance. The marked effect of a left to right shunt is shown in Figure 19*A*, a case with a large interatrial septal defect. The markedly enlarged, globular-shaped heart with the dilated pulmonary trunk and the relatively small aorta are characteristic. In lateral and oblique views, the marked evidence of right ventricular enlargement and the absence of left atrial and left ventricular enlargement are all characteristic of the condition. In addition, the extreme distention of the pulmonary arteries is readily visible. Figure 19*B* illustrates the condition in the same patient five days after repair of the septal defect. This is an example of a simple roentgenogram of the chest exhibiting pathological physiology. One must note here the striking change in the shape of the heart, which now shows a much smaller pulmonary trunk and a diminution in the size of the right ventricle, while the left ventricle is seen extending out to the left. The great difference is the result of the marked change in the dynamics within the heart. As long as there was a large interatrial septal defect with a shunting from left to right, the left ventricle was under much lower pressure and strain and as a result was very small. The right ventricle, however, carrying a much greater load of blood than in the normal was greatly enlarged, as was the right atrium. Since the left atrium is only a way station which passes its blood both into the right atrium and into the left ventricle, it does not enlarge under these circumstances. Likewise, the aortic arch is small because from the very beginning of life, there is a relatively small output of the left ventricle. At the same time, the pulmonary arteries are greatly dilated because they, too, carry

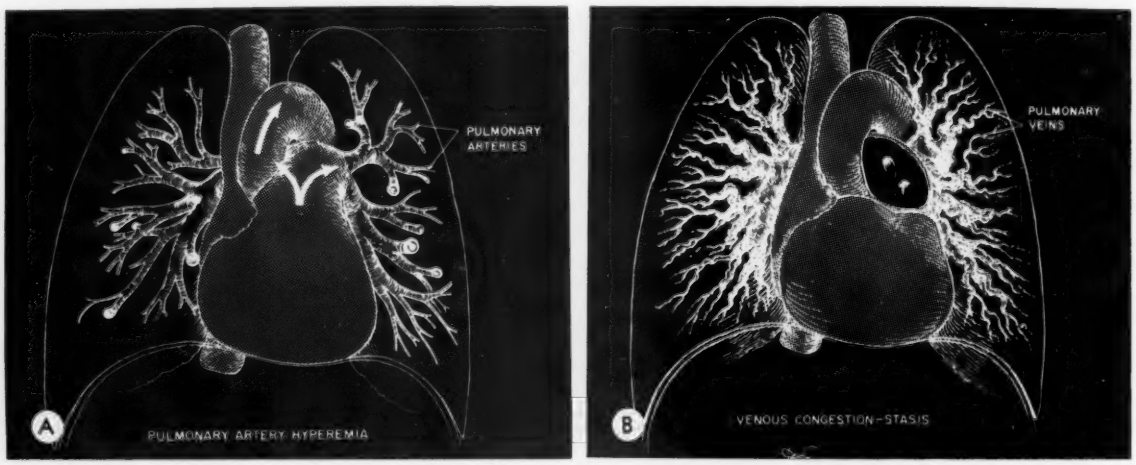

Fig. 18. Diagrams showing abnormal enlargement of pulmonary arteries and veins. (*A*) Enlarged arteries such as might occur with a left to right shunt or in the early stages of pulmonary hypertension Note the sharply defined, clear, fairly straight shadows, some of which appear as rounded densities because they are seen on end. (*B*) Extreme degree of venous stasis such as might occur with left heart failure. The interstitial and alveolar edema of the lungs as well as the tortuous, irregular course of the veins makes them difficult to see in the roentgenogram. The contrast between vessel and lung is largely lost.

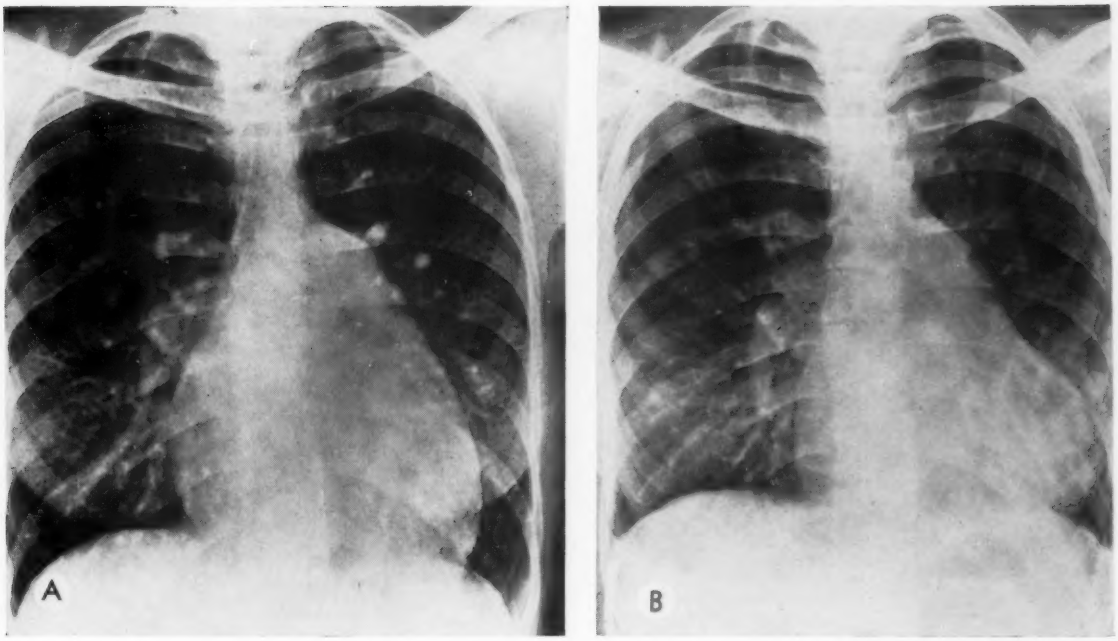

Fig. 19. Interatrial septal defect with marked left to right shunt, before and after surgery. (*A*) Enlarged globular-shaped heart, markedly enlarged pulmonary trunk and diminished size of aorta are all characteristic. In the lateral view there was no evidence of left atrial enlargement. The pulmonary arteries are all greatly enlarged and illustrate the findings in Figure 18*A*. (*B*) Same case five days after surgical closure of the defect. Note the marked change in the contour of the heart, its diminution in size and the marked diminution in size of the pulmonary arteries as a result of the elimination of the left to right shunt. The beginning enlargement of the left ventricle can be seen.

a double load. The elimination of the defect promptly reduces the work on the right side and increases it on the left. The elastic pulmonary arteries immediately are reduced in size.

In an interventricular septal defect, a somewhat different situation pertains. A case of a fairly large interventricular septal defect with a left to right shunt is shown in Figure 20, *A* and *B*. The heart here is also enlarged but, as seen in both the postero-anterior and lateral views, there is enlargement of the left atrium and moderate enlargement of the left ventricle as well as enlargement of the right ventricle. The aortic arch is normal in development. The pulmonary vessels are enlarged but not to the same degree as in the interatrial septal defect. The reason for these differences is apparent when one considers the pathological physiology which is demonstrated in Figure 21, *A* and *B*, two diagrams illustrating the two conditions. With the shunt going from the left atrium to the right, there is simply an increased pulmonary blood flow but little or no increase in pressure on the right side. The right ventricle is carrying a much larger load but the left ventricle carries a rather smaller load because the total output is probably diminished on both sides. In the defect which lies between the two ventricles, there is, in addition to the increased pulmonary blood flow from the right side, an increased pressure. At the same time, the left ventricle is carrying a much larger load since it must expel not only its normal amount of blood but that amount which is lost to the right ventricle as a result of the defect. With the enlarged left ventricle, there comes enlargement of the left atrium and a normal development of the aorta.

I do not wish to go into the question of congenital heart disease to any great extent, although in this group of cases one may find the best illustrations for the

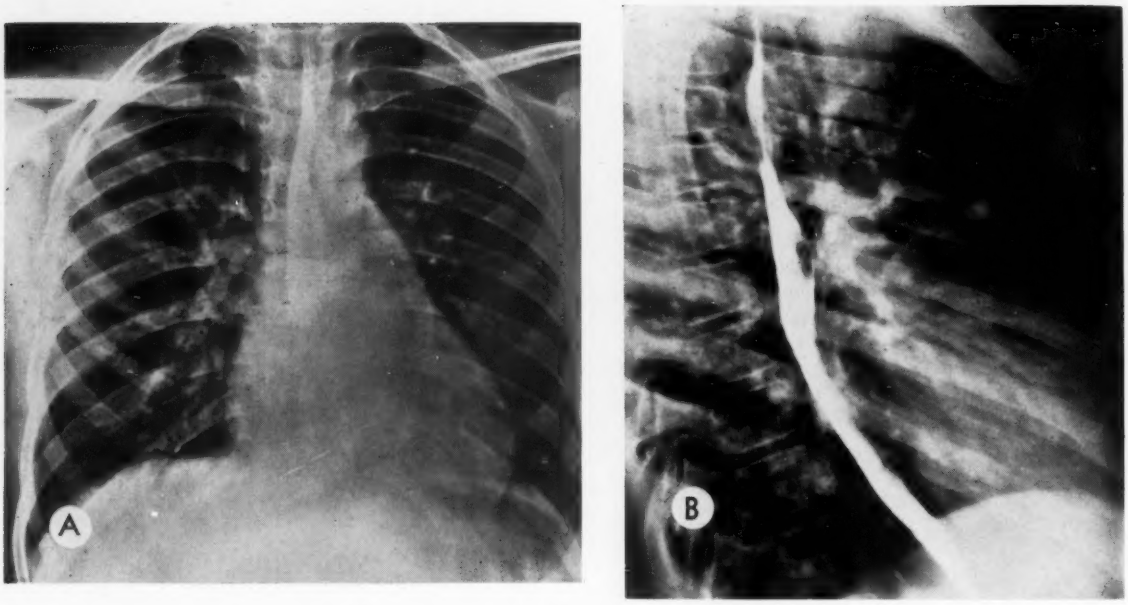

Fig. 20. Interventricular septal defect of moderate degree. (*A*) Posteroanterior view. The difference in the contour of the heart as compared to that of an interatrial defect is well shown. Note particularly the fairly well developed aorta and the projection of the left ventricle. The pulmonary arteries are enlarged but their distention is not nearly as marked as in interatrial septal defect. (*B*) Lateral view showing definite enlargement of left atrium with compression of esophagus. This is much more characteristic of interventricular than of interatrial septal defect.

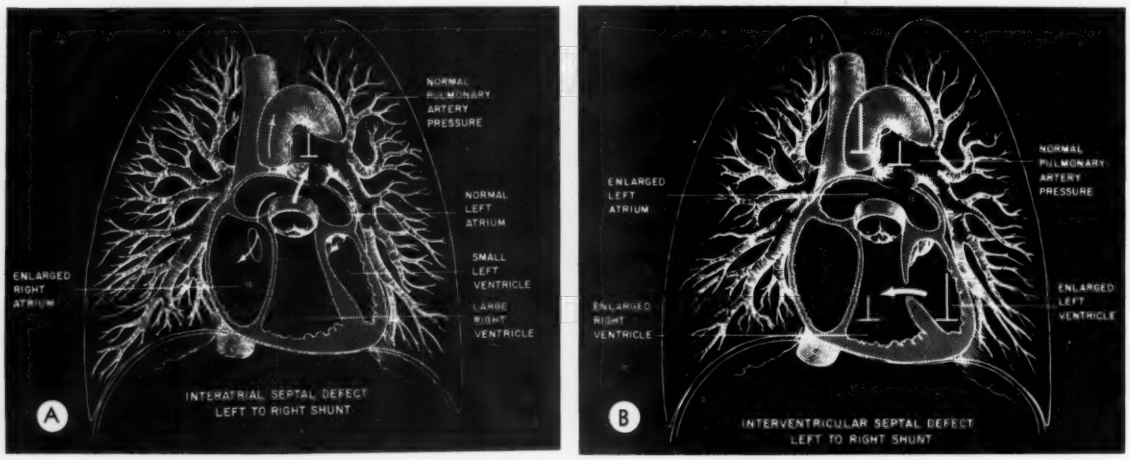

Fig. 21. Diagrams illustrating difference between interatrial and interventricular septal defect. (*A*) Interatrial septal defect showing shunting of blood from left atrium to right atrium with consequent diminution in quantity of blood handled by the left ventricle which is relatively small. The pressure is not increased in the right ventricle, however, because there is no communication with the left. The output through the pulmonary artery is greatly increased because of the increased volume of blood resulting from the left to right shunt. The output from the left side is diminished for the same reason. (*B*) Interventricular septal defect. The increased output into the pulmonary vessels is shown by their distention. The enlargement of the left ventricle occurs because of the increased load which it must bear owing to the shunt into the right ventricle. Under these circumstances, the pressure in the left ventricle is higher than that in the right, but the pressure in the latter is somewhat higher than normal.

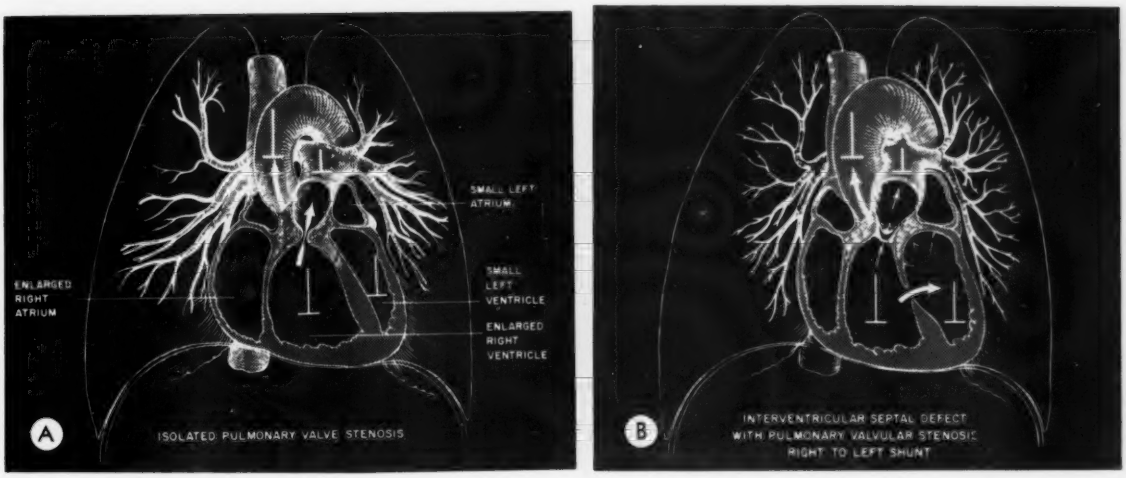

Fig. 22. Diagrams showing effects of pulmonic stenosis. (*A*) Isolated pulmonic stenosis. There is an impediment to the passage of blood from the right ventricle into the pulmonary artery but the increased pressure of the right ventricle overcomes this to a large extent so that the output is not much diminished and the size of the pulmonary vessels remains normal or moderately decreased. (*B*) Pulmonary valve stenosis with interventricular septal defect. In addition to the obstruction at the pulmonary valve, there is now a shunt from the right ventricle to the left. The pressure in the right ventricle is slightly greater than in the left because of the pulmonic stenosis. Because of the shunting, however, the amount of blood extending into the pulmonary vessels is decreased and the size of the pulmonary arteries is diminished.

thesis which I am propounding. It may be worthwhile, however, to examine the difference between an isolated pulmonic stenosis and a pulmonic stenosis with a septal defect insofar as the effects upon the pulmonary circulation are concerned. In a simple isolated pulmonic stenosis without a shunt, the pulmonary circulation may approach the normal and the diminution which may be present is difficult to determine. The reason for this is obvious since the pressure in the right ventricle is greatly increased and tends to overcome the obstruction which is present. The output from the right ventricle must be the same as on the left side, and, if a good circulation is maintained to the periphery, a good circulation and pulmonary blood flow must be maintained to the lungs. As soon as there is a shunting mechanism which permits blood to flow from the right to the left side, a marked change occurs since now the pulmonary circuit does not bear the same amount of blood as the peripheral circuit. As a result, in all cases where there is both a septal defect, that is, a right to left shunt, together with stenosis, the pulmonary arteries are greatly diminished in size (Fig. 22, *A* and *B*).

Diminished vascular shadows in the lungs may be seen under a variety of conditions. It has already been noted that these occur when there is a right to left shunt with pulmonic stenosis. The most common example of this, of course, is the classic tetralogy of Fallot. A similar diminution of circulation may be observed in pulmonary hypertension after severe changes in the peripheral pulmonary arteries have taken place. Under these circumstances, however, the major branches of the pulmonary arteries and the pulmonary trunk are usually very greatly increased in size and the heart is also rather large. The observation of diminished pulmonary circulation with a very small, rather normal-appearing heart, and without evidences of emphysema or other changes of the lungs to account for it, may lead to another conclusion. If the findings are unilateral, one may consider the possibility of hypoplasia or atresia of one pulmonary artery. A similar process may be found when there is a unilateral thrombosis of the pulmonary artery. In the

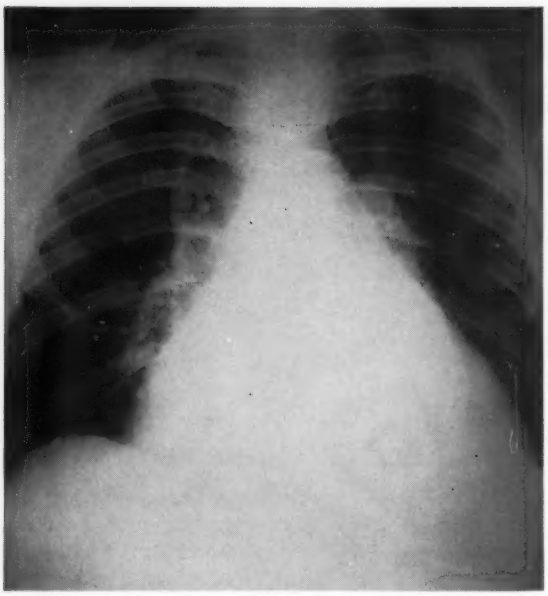

Fig. 23. Massively enlarged heart from multiple valve disease with relatively small increase in pulmonary circulation. The size of the heart is in striking contrast to the moderate changes in the pulmonary vessels. This results from the fact that there is a good balance between the two sides and the left atrium instead of the lungs becomes the reservoir for blood.

same way, local areas of what appear to be lung ischemia occur, although rarely, with embolism of a branch pulmonary vessel. When the diminution in circulation is bilateral and the heart is small, one can only conclude that there has been a diminished output as a result of a marked lowering of blood pressure. This may be clearly observed in cases of Addison's disease before treatment. With the institution of adequate treatment, the changes in the pulmonary circulation and in the size of the heart may demonstrate vividly again the possibilities of observation of the pathological physiology of the cardiorespiratory system.

The finding of a massively enlarged heart without much evidence of vascular engorgement is always intriguing. Usually this is seen in patients with multiple valvular disease, although occasionally it may occur in certain cases of severe involvement of the mitral valve alone, after repeated failure. Such a case is illustrated in Figure 23 in which the massive enlargement of the heart is not accompanied by any considerable enlargement of the pulmonary veins or even of the arteries. In this situation with both mitral and tricuspid valve involvement and some involvement of the aortic valve as well, one can readily conclude that there is a massive enlargement of the left atrium and, as a result, the stasis of blood is now in the left atrium itself and not in the lungs. Since both sides have failed and a balance between the two has been achieved, there is no impediment to the passage of blood from the right heart to the left and hence no pulmonary congestion.

The presence of a very large cardiac shadow with diminished pulmonary circulation as illustrated in Figure 24 is even more intriguing but again a careful analysis of the findings may explain this apparently paradoxical situation. It is evident at once that the shape of this heart suggests a pericardial effusion. Since there is no evidence of a congenital lesion, one may well conclude that this has now gone to the point of tamponade so that the output from the right heart is greatly impeded and the pulmonary blood flow is therefore di-

Fig. 24. Massive enlargement of cardiac shadow with diminished pulmonary circulation. Pericardial effusion is present. It has produced a tamponade of the heart so that the output into both the right and left sides is diminished and the pulmonary vessels, therefore, are reduced in size.

Fig. 25. Patient with tetralogy of Fallot with multiple operations. Analysis of posteroanterior roentgenogram. The contour of the heart and its moderate increase in size is fairly consistent with that commonly seen with tetralogy of Fallot. A right aortic arch is also visible. The pulmonary circulation on the right is diminished considerably throughout but there is distortion with one pulmonary artery branch pulled upward. In addition, on the right side, erosion of a scalloped character in the inferior portions of the posterior ribs can be made out. On the left side, the pulmonary artery is increased in size and the circulation to the left lung is moderate, almost within normal limits. The left pulmonary artery, however, is greatly elevated and distorted. There is no rib erosion. The patient had had an anastomosis on the right side which had closed by thrombosis; collateral circulation with erosion of the ribs resulted. The left anastomosis was functioning to some degree, but there was still marked cyanosis.

minished. As a result, the pulmonary arteries contract and the appearance of ischemic lungs is produced.

Finally, I would draw your attention to the changes which can be observed if one makes roentgenograms in patients with congenital heart disease, before and after operation, or after secondary effects. A simple illustration has already been exhibited in Figure 19, *A* and *B*, an interatrial septal defect which was successfully closed with an excellent result. In the case of the tetralogy of Fallot, striking changes in the pulmonary circulation occur, either after an anastomosis between the pulmonary artery and peripheral circulation has been achieved or after definitive correction of the pulmonary stenosis and the septal defect has been performed. The pulmonary vessels enlarge markedly, returning to their normal size. The heart as a whole increases in size and changes its contour as a result of a specific enlargement of the left ventricle. The possibilities of physiological interpretation of simple roentgenograms of the thorax in such instances are illustrated in Figure 25, a case of tetralogy of Fallot, in which some operative procedures had been undertaken some time before the patient came in for a definitive operation. With only this knowledge, it is possible to predict almost exactly what has taken place. The roentgenogram shows the heart moderately enlarged, the shape being characteristic of the congenital defect. The vascular pattern of the left lung is approximately normal in size, but the left pulmonary artery is enlarged, elevated and distorted. In the right lung, however, the vascular pattern is greatly reduced and also shows some distortion. In addition, there is seen an erosion of the inferior margin of the right posterior ribs. With such findings, it is possible to postulate that two previous surgical procedures had been done. First, there was a conventional Blalock operation on the right side. This became thrombosed and the pulmonary-peripheral anastomosis was closed. As a result, a collateral circulation was set up which eventuated in dilatation of the intercostal arteries; hence the erosion of the inferior surface of the posterior ribs. An anastomosis was then done on the left side between the aorta and the pulmonary artery, which has been moderately successful, increasing the circulation to the left lung but giving no added circulation to the right. The patient, therefore, is moderately cyanotic even though this palliative procedure had been partially successful. Operative intervention revealed the correctness of this interpretation and a definitive operation was then undertaken in order to actually cure the patient.

The various situations cited above merely serve to illustrate some of the possibilities of such an expansion of interpretation and indicate the kind of information which can thus be obtained. For the radiologists of my generation, often confused and overwhelmed by the welter of new methods and complicated new procedures, it may be comforting to re-discover the tremendous amount of information that can be gleaned from conventional roentgenograms. For the younger generation, there is here a challenge: the study of the roentgenogram in terms of physiology, in terms of a living process. There is a great opportunity to use initiative, energy and imagination to investigate the further possibilities, the still undiscovered potentialities in the interpretation of simple roentgenograms. We must learn to extract physiological as well as pathological information, in fact, every shred of information, from the smallest number of roentgenograms made with the least amount of effort. I would reiterate that I do not wish to raise any doubts whatever as to the desirability of newer procedures which are often necessary, frequently indispensable. But I would appeal for the complete utilization of conventional fluoroscopy and roentgenography by means of intensive study and logical analysis based upon the principles of physiology as well as the facts of anatomy and pathology.

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I am grateful to Doctors Harold Peterson and Richard Lester of the University of Minnesota for their material, and to my colleagues at the Cedars of Lebanon Hospital for the privilege of presenting some of their cases. I am particularly thankful to Doctors Andrew Dowdy and B. J. O'Loughlin for the free use of the case material and facilities of the University of California at Los Angeles.

The drawings here reproduced were the work of Mr. Ted Bloodhart of the Department of Visual Education of the University, to whom I am greatly indebted.

REFERENCES

1. Bockus, H. L. Role of roentgenology in gastroenterology; Caldwell Lecture, 1950. Am. J. Roentgenol. & Rad. Therapy, 1951, *65*, 853–866.
2. Brown, P. American Martyrs to Science through the Roentgen Rays. With a Short Glossary of the Scientific Terms Used in the Text. Charles C Thomas, Publisher, Springfield, Ill., 1936.
3. Comroe, J. H., Jr. The Lung: Clinical Physiology and Pulmonary Function Texts (Based on the 1954 Beaumont Lecture). Year Book Publishers, Inc., Chicago, 1955.
4. Golden, R. Radiologic Examination of the Small Intestine. J. B. Lippincott Company, Philadelphia, 1945.
5. Hickey, P. M. The Caldwell Lecture, 1928. Am. J. Roentgenol. & Rad. Therapy, 1931, *25*, 177–195.
6. Rigler, L. G. Roentgen study of evolution of carcinoma of lung. *J. Thoracic Surg.*, 1957, *34*, 283–297.
7. Wasson, W. W. The Auxiliary Heart. Charles C Thomas, Publisher, Springfield, Ill., 1954.
8. Westermark, N. Roentgen Studies of the Lungs and Heart. A Series of Lectures Delivered at the Center for Continuation Study, University of Minnesota. Edited by Leo G. Rigler. University of Minnesota Press, Minneapolis, 1948.

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STUDIES ON THE ACCURACY OF DIAGNOSTIC PROCEDURES*

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"And why beholdest thou the mote that is in thy brother's eye, but considerest not the beam that is in thine own eye? . . . First cast out the beam out of thine own eye; and then shalt thou see clearly to cast out the mote out of thy brother's eye."

—Mathew VII, 3, 5

DURING the past fifteen years several investigations have revealed the fact that a surprising and clinically important degree of inaccuracy is to be expected in the interpretation or evaluation of many clinical and laboratory procedures used in every day practice. The mere existence, far less the extent, of the ensuing diagnostic error is little appreciated. Some of the more noteworthy of the investigations include the following (Table 1).

Paton,[21] at the Royal Infirmary in Edinburgh, studied a series of over 1,000 patients who had been admitted with a clinical diagnosis of myocardial infarction. Autopsy was performed on 214 of the patients who died; the diagnosis of infarction was confirmed in only 118. Conversely, infarction was revealed at autopsy in 52 patients in whom it was unsuspected clinically. The accuracy rate in the diagnosis of myocardial infarction was 44 per cent. However, many of the cases were acutely ill and difficult to examine; electrocardiograms were not available in all. Nevertheless, Paton regarded the degree of error as surprising.

Fletcher,[9] at the London Postgraduate Medical College, arranged with 8 experienced internists (all Fellows or members of the Royal College of Physicians) to examine the chests of 20 patients with emphysema, in order to assess the validity of well known physical signs. Agreement on the presence of the most simple signs was observed in only 15 per cent of the tests. Many signs produced only a two-thirds agreement, which he felt was not much better than chance. In this study, the observer's final integration of all the separate signs into a diagnosis of emphysema showed no better consistency than did the individual signs, so that integrated conclusions were not more consistent than the isolated observations upon which they were based.

Bakwin[1] reported a study of 1,000 school children regarding the advisability of tonsillectomy. Of these, some 611 had had their tonsils removed. The remaining 389 were then examined by other physicians, and 174 were selected for tonsillectomy. This left 215 children whose tonsils were apparently normal. Another group of doctors was put to work examining these 215 children, and 99 of them were adjudged in need of tonsillectomy. Still another group of doctors was then employed to examine the remaining children, and nearly one-half were recommended for operation. In the end, there were only 65 of the original 1,000 whose tonsils had not been either removed or recommended for removal. Bakwin concluded that there was no correlation between the estimate of one physician and another regarding the advisability of tonsillectomy; he added that economic conditions played no part in the recommendations in this particular series.

Derryberry[6] reported a study of 221 children by 5 experienced pediatricians who were asked to classify them according to nutritional status. They made complete clinical examinations and employed such diagnostic aids as they desired. In the entire series, the number of children reported as suffering from malnutrition varied from

* Presented as a Mayo Foundation Lecture, Mayo Clinic and Mayo Foundation, Rochester, Minnesota, May 15, 1958.
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TABLE I

SUMMARY OF FINDINGS IN 5 CLINICAL TESTS AND 4 LABORATORY TESTS DEALING WITH OBSERVER ERROR

1. Diagnosis of Myocardial Infarct (Paton[21]) 214 autopsied patients	56% error
2. Diagnosis of Emphysema (Fletcher[9]) 20 patients, 8 expert internists	33–85% disagreement on simple signs
3. Disease of the Tonsil (Bakwin[1]) 389 children, 3 groups of observers	174–324 recommended for removal
4. Nutritional Status (Derryberry[6]) 221 children, 5 pediatricians	malnutrition 90 range 32–47 agreed by all interpreters 7
5. Taking of Medical Histories (Cochrane and Garland[4]) 993 miners, 4 observers	Per cent reported with cough 23–40 sputum 13–42 dyspnea 10–18 pain 6–17
6. Interpretation of Electrocardiograms (Davies[5]) 100 sets, 10 observers (including 9 experienced cardiologists), dual readings	20% error, both inter- and intra-individual
7. Clinical Laboratory Procedures (Belk and Sunderman[2]) Standard samples to 59 hospital laboratories	Material / Per cent gross error Hb 22 glucose 10 protein 15 calcium 28
8. Radiation Effect on Thyroid Gland (Miller *et al.*[19]) Treated and untreated thyroid gland in a series of 39 patients	false positive 4% false negative 27%
9. Erythrocyte Counts (Magath *et al.*[18]) (Conclusion of clinical pathologists: "Impossible")	16–28% gross variation

32 to 47, and these were not the same cases. There were 90 in which one or the other examiner diagnosed malnutrition, but only 7 in which all 5 examiners agreed.

Cochrane and Garland[4] reported a study of observer error in taking medical histories. Approximately 4 physicians interviewed 993 coal miners concerning certain common symptoms. The observers asked the miners the same questions. The following range in response was recorded: cough —23 to 40 per cent; sputum—13 to 42 per cent; dyspnea—10 to 18 per cent; pain—6 to 17 per cent. Conversely, when questioned concerning previous disease, there was a wide variation in the consistency of recording bronchitis, pleurisy, pneumonia and dyspepsia. The investigation showed that the history recorded is very liable to be biased by the attitude of the recorder, and that answers to even the simplest questions are not always reproducible.

Davies[5] studied variations in the inter-

pretation of electrocardiograms. The sample included 50 which had been routinely reported as indicating infarction, 25 as normal, and 25 as showing various abnormalities other than infarction. Nine experienced and one less experienced physician interpreted the 100 sets of tracings, being given the choice of reporting them as normal, abnormal, or showing infarction. Some weeks later the observers read the tracings again. Disagreement was found in all three categories. There was general or majority agreement on four out of every five tracings, but the fifth gave rise to considerable dispute. There was as much difficulty in deciding between normal and abnormal, as there was between abnormal and infarction. Each observer's working definition varied, since after the second reading all were found to have changed their opinions in a proportion of the tracings. The author concluded that certain leads and patterns are particularly controversial, and that the diagnostic value of the single electrocardiogram (when these leads are involved) may be much less than is generally realized.

Belk and Sunderman[2] conducted a notable study of the results of chemical analyses of standard solutions in 59 different hospital clinical laboratories. The results showed wide variation of the reports of the different laboratories, the extent of gross error ranging from 5 to 28 per cent.

Miller, Lindsay and Dailey[19] studied the reliability of pathologic diagnosis of radiation effect on treated and untreated thyroid glands in a series of 39 patients (seen at the University of California). They concluded that their error rate was significant—some 4 per cent of false positive diagnoses, and 27 per cent of false negative readings. After their test-retest studies, they concluded that histologic criteria in this field needed considerable refinement.

Magath *et al.*[18] studied fluctuations of the erythrocyte count under standard laboratory conditions. They reported a gross variation ranging from 16 to 28 per cent, depending in part on the degree of training of the technician. When confronted with the results of the erythrocyte study, some pathologists made the same observation that many clinicians had made relative to the first mentioned investigations: "Impossible." Most clinicians believe that in their own field such a degree of error or percentage of variation in accuracy is unthinkable.

ROENTGENOGRAPHIC STUDIES

When the effectiveness of different roentgenographic methods for purposes of mass survey was studied in the early part of World War II, it was found that the size of the recording medium (35 mm. or 14 inch × 17 inch film) was less important than the degree of observer variation. When 5 expert physicians interpreted series of films in the different film sizes, all interpreters under-read (or missed) approximately 25 per cent of the positive films in each series[3] (Table II). When the same films were read again after about three months, a reader was apt to change his mind once in every five of the positive cases (a degree of intraindividual inconsistency of 20 per cent). By "positive" is meant positive for roentgenographic evidence of pulmonary disease, presumably active. Astonished by these findings, two different groups of experienced radiologists* studied the question further and concluded that the original observations were indeed correct.[11,20] Professor J. Yerushalmy, distinguished biostatistician, guided the groups in these studies,

TABLE II

VARIATIONS IN INTERPRETATION OF CHEST ROENTGENOGRAMS
(mostly unselected survey material)

Author	Per Cent Under-Reading of Positives	Per Cent Over-Reading of Negatives
Birkelo *et al.*[3]	25	—
Garland *et al.*[13]	27	1.7
Yerushalmy *et al.*[26]	32	1.7
Groth-Petersen *et al.*[14]	32	2.0
Danish Tuberculosis Index, Bull. W.H.O., 1955	—	1.6

* Group 1: W. E. Chamberlain, L. G. Rigler, R. R. Newell. Group 2: L. H. Garland, E. R. Miller, H. B. Zwerling.

published several additional reports[24,25] and established the fact that dual interpretation significantly reduced the degree of under-reading.[26]

In all of the above tests, experienced radiologists were involved. Garland (1947) reported the results of some tests using readers of different degrees of training. He found that 2 expert readers missed about 9 per cent of roentgenologically positive films in one selected series of standard-sized chest roentgenograms; 3 readers with moderate training missed approximately 25 per cent of such films; and 2 physician readers of little experience missed some 44 per cent of these positive films. In 1950, the same author[12] reported further studies conducted with the invaluable aid of Dr. M. A. Sisson. Experienced readers were used and revealed the following: under-reading ranged from 26 to 43 per cent in an unselected series of standard-sized films; over-reading ranged from 0.9 to 2.7 per cent.*

These surprising results were confirmed by a Danish group of workers under Groth-Petersen—in a study of 5,000 unselected minifilms, read twice by 3 experienced readers of photofluorograms.[14] They found an average degree of under-reading of 32 per cent and over-reading of 2 per cent.

Cochrane, in England, also confirmed these observations.[4]

When other radiologists were confronted with these results, their usual reaction was, "Well, in my everyday work this does not apply," or "If I took these tests, I would do better than those busy investigators." Indeed, this was my own initial reaction. A few investigators thought that perhaps the results were true, in which case the less said the better!

* Error can be measured in different ways. For example, if a series of 100 roentgenograms contains 10 positive and 90 negative films, and a reader misses 3 of the positive films and over-reads 2 of the negative films, he may be regarded by one standard as having only a 5 per cent error. (The over-all accuracy of competent radiologists in survey procedures has been shown to be of this order.) On the other hand, since the series of 100 roentgenograms is being examined to detect patients with disease, the reader who misses 3 of the 10 positive films has an error rate of 30 per cent. This is the criterion for measuring under-reading in this paper. Coupled with an over-reading of 2 of the 90 negative films, the combined error rate in the example mentioned is about 32 per cent.

TABLE III

INTERPRETATION OF CHANGE IN SERIAL 14×17 INCH CHEST ROENTGENOGRAMS

Disagreements between expert readers (inter-individual)—and of one reader with himself (intra-individual)—as to whether disease was better, worse or unchanged

	Inter-Individual (different readers paired)	Intra-Individual (same reader's first and second readings)
Disagreements	2,686 (30%)	192 (21%)
Agreements	6,245	701
Total Comparisons	8,931	893

We next took part in a study of the observer error problem in the evaluation of *serial* chest roentgenograms, using standard size films from every-day sanatorium and clinic practice (Fig. 1). As a result of this study, it was concluded that in interpreting a pair of serial roentgenograms (for evidence of improvement, worsening, or absence of change) 2 experienced physicians are likely to disagree with each other in about 30 per cent of the cases, and a single interpreter is likely to disagree with himself in about 20 per cent of the pairs (Table III).

Further, in this serial study the performance of 3 experienced radiologists was found to be *not* remarkably better than that of 3 expert phthisiologists (Table IV).

An editorial in the *Lancet* for January 9, 1954 commented on the above observations, and opined that the practical signif-

TABLE IV

COMPARISON OF PERFORMANCE OF TWO GROUPS OF SPECIALISTS IN INTERPRETATION OF SERIAL 14×17 INCH ROENTGENOGRAMS (DISAGREEMENTS)

	Inter-Individual (per cent)	Intra-Individual (per cent)
Group A	29	19
Group B	27	24

Note: One group consisted of radiologists, the other of chest specialists.

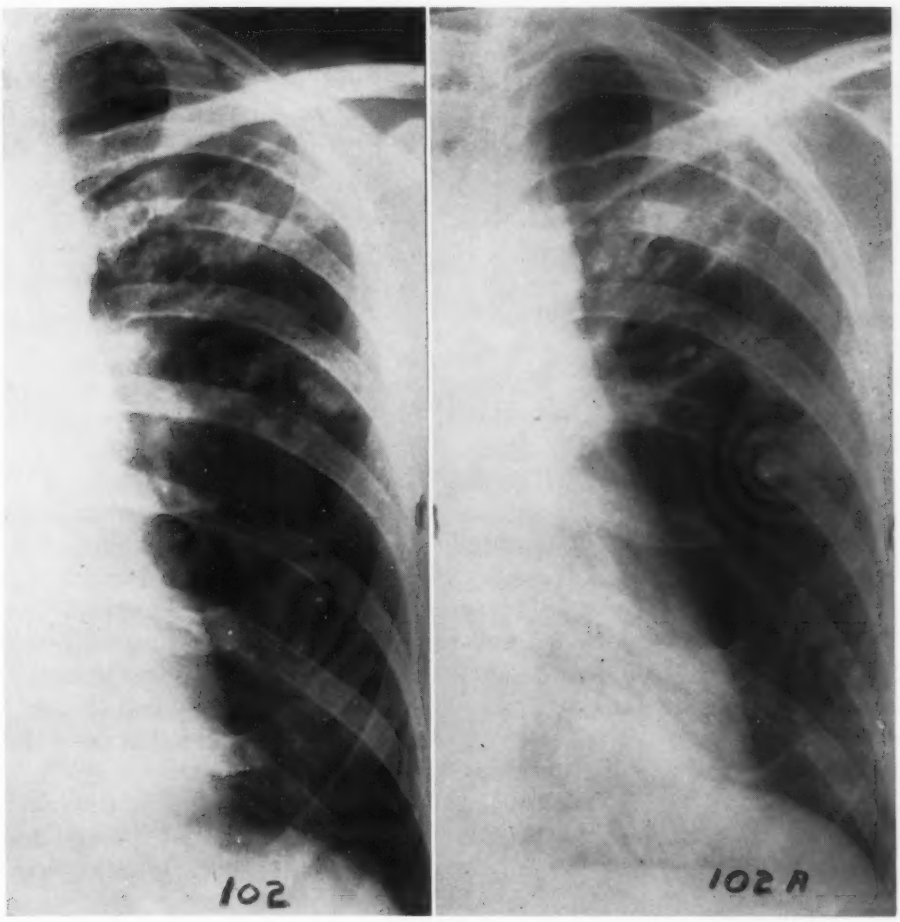

Fig. 1. Example of disagreement or error in interpretation of serial roentgenograms. Male with chronic pulmonary tuberculosis under medical treatment. Roentgenogram on right made three months after that on left. Three experienced radiologists and three experienced chest specialists interpreted the pair of roentgenograms on two separate occasions. Four interpretations of the roentgenographic appearances in the second film (102 A) were summarized as *worse*, two as *no change*, and six as *better*. The interpretations of "worse" were probably based on the fresh lesions noted at the level of the third space. The interpretation of "no change" was probably based on the fact that the new lesions represent only a small fraction of the total volume of disease present. The interpretations of "better" may have been due to the decrease in size of the cavity at the level of the first space.

icance of these factors in general medicine is probably "very small."[8] "Action," it read, "seldom follows on the result of a single observation, and the discussion, consultation and re-examination that usually precedes a final diagnosis or decision greatly reduce the hazard from this sort of error." This is indeed optimism, with the parable of the beam and the mote ignored. All of us are familiar with examples of action based upon a single positive electrocardiogram, bronchoscopy, biopsy or other test. *Although the errors of all of these procedures* have not yet been submitted to statistical analysis, there is no reason to expect them to be less than those of clinical chest examinations or clinical radiology!

To paraphrase Fletcher, many clinicians continue to believe that their observations are accurate, and are unaware of the need for consultation and re-examination to reduce error. They feel that laboratory and roentgen "tests" may be subject to faulty interpretation, but not careful "observation." "Not only should clinicians recognise their own errors; they should admit them

in their teaching. Students should be taught obvious and useful signs, and not waste their time upon refinements, which must be subject to gross errors. Diagnostic procedures should be subjected to the test of observer error before they are published in textbooks and taught to students."[10]

PARALLEL OBSERVATIONS

Most of us assume that, except in occasional borderline instances, the signs we observe are present and those we do not observe are absent. Two simple examples of nonmedical perception are used by Johnson[17] to illustrate the fact that a "sign" may be present at one time and absent at another *for the same observer*. One of these is the "Three Triangles" of Brooks (Fig. 2), which illustrate the fact that we tend to notice only those things to which we attribute significance; what is seen depends on the store of information the observer brings to the perceptual act.

The second example shows the "Hidden Man" of Porter (Fig. 3). This illustrates the fact that what is seen often depends on the information supplied with the pattern. To decipher the shadows one should realize that the upper edge of the picture transects the eyebrows, and that a white serape is draped over the right shoulder.

We may be surprised to note that we have missed 3 simple words in one figure, and a face and shoulder in another. We saw them but did not recognize them, perception being a process involving judgment as well as seeing. Left to ourselves, most of us would not doubt that we had read Figure 2 correctly the first time, and that Figure 3 was perhaps a Rorschach test. By re-reading, or discussion, the truth may be discovered.

FIG. 2. The "Three Triangles" of Brooks. (Courtesy of R. A. Brooks and *This Week*. Reproduced by permission of the author and publisher.)

FIG. 3. The "Hidden Man" of Porter. (Porter, P. R. Another puzzle picture. *Am. J. Psychology*, 1954, *67*, 550. Reproduced by permission of the author and publisher.)

Johnson[17] concludes that observer skill may be improved by groups of readers discussing their interpretations of the same material, by attempting to describe the features they use in coming to their decisions, and by testing the probability of their conclusion against other findings—for example, in patients under examination.

FURTHER ROENTGENOGRAPHIC STUDIES

A few years ago, we took part in a study* to determine whether one could answer the question "How often should minifilms be made on University students to detect pulmonary tuberculosis?" It had been customary to make chest minifilms on students at that University once in four years, *i.e.*, at the time of registration as freshmen. A few of those students whose minifilms had been interpreted as negative subsequently developed tuberculosis. Would films made annually or more often have aided in the earlier detection or prevention of some of these? If so, what periodic program should be set up?

The method of study was as follows: a 70 mm. photofluorogram was obtained on each of almost 15,000 students who registered in the spring semester. Each photofluorogram was read ten times by 8 different readers, 6 of whom rendered a single reading, and 2 a dual independent reading. The readers were 50 in number, equally composed of radiol-

* Conducted by J. Yerushalmy, who kindly made available the findings herein summarized.

ogists and chest specialists; each provided an average of 3,000 readings according to a randomized scheme assuring 10 interpretations of each film. The readers were asked to indicate as "positive" those photofluorograms with a potentially significant pulmonary shadow of which they would like a subsequent film. Every student whose photofluorogram was interpreted as "positive" on *two or more of the ten readings* was recalled for a standard 14 by 17 inch roentgenogram. If only a single reading was positive, the photofluorogram was reviewed by a group of 3 and on the basis of their decision the student was either recalled for a 14 by 17 inch roentgenogram or not. All the 14 by 17 inch roentgenograms were interpreted independently by 3 experts. If at least 2 of the 3 readings were "positive," clinical follow-up was initiated. If only one of the readings was "positive," a review by the experts decided whether the student should be recalled for clinical follow-up. As a result of these activities, 249 students were identified as having roentgen shadows requiring further clinical study. These students may be referred to as "roentgenologically positive" in the sense that their roentgenograms showed evidence of possible inflammatory or other disease. They were than given supplementary examinations such as tuberculin tests, bacteriologic examinations and other studies, and were requested to report for further tests periodically for the duration of their stay at the University. In addition, in order to aid in developing a test strip for minifilm readers, some 1,500 photofluorograms were interpreted independently 24 times.

Most of the minifilms ultimately called "roentgenologically positive" proved to be of students already known to have roentgenographic evidence of pulmonary abnormality (persons currently or formerly under medical care, including a few young men with prior chest injuries or surgical procedures, etc.). This does not interfere with the conclusions pertinent to observer error. It is of interest to note that only 8 students or 3.2 per cent of the "roentgenologically positive" cases were adjudged active (on bacteriologic and/or clinical grounds) at the end of the survey. One half of these (or 4 cases) were previously known to be active. The survey therefore yielded 4 previously unknown active cases or a rate of approximately 0.26 per 1,000.

RESULTS

Some of the findings may be summarized by reference to Tables V, VI, VII and VIII.

The degree of variation between individual readers was of course considerable; some readers read 3 times as many films as "positive" as did other readers. In the main part of the study (but prior to the dual readings by the same reader) some 243 roentgenologic "positives" were detected.

Table V

INTERPRETATIONS OF PHOTOFLUOROGRAMS

Total no. of 70 mm. films	14,867
No. called "positive" by one or more readers	1,307
No. agreed as "roentgenologically positive"	249
Average degree of under-reading	39%
Average degree of over-reading	1.2%

Table VI

UNDER-READING AND OVER-READING

Cases Determined to Be:	No.	No. of Readings	No. of Positive Readings	No. of Negative Readings	Per Cent False Negative Diagnoses	Per Cent False Positive Diagnoses
Negative	14,458	115,664	1,216	114,448		1.1
Roentgenologically Positive	243	1,944	1,208	736	37.9	
Clinically Active	12	96	72	24	*25.0*	

TABLE VII

PERSONAL (INTRA-INDIVIDUAL) VARIATION

Of 10,000 Films Double Read
628 were called positive on one or both of two readings
247 were called positive each time
381 were called positive once and negative the other time
Of 224 Generally Agreed Positive Films
168 were called positive each time (75%)

Of these, 154 were regarded as "strongly positive," for the reason that 3 out of 3 independent expert interpreters called the corresponding 14 by 17 inch roentgenograms positive. Eight of these were clinically active at the time of the survey; 4 became active subsequently.

The extent of under and over-reading may be noted from Table VI. The degree of under-reading decreased as the "positivity" of the films increased. Note that the percentage figures refer respectively to the "positive" and the "negative" films only.

The extent of personal variation was demonstrated by comparing the first and second readings of approximately 10,000 minifilms. The findings are summarized in Table VII.

Since the panel of interpreters was made up of radiologists and phthisiologists, it may be of interest to note the "scores" of the 5 apparently "best" readers in each group (see Table VIII). By contrast, it will be remembered that the average degree of under-reading was 39 per cent and of over-reading 1.2 per cent. The worst score of one reader in these two categories was 82 per cent and 3.9 per cent, respectively.

TABLE VIII

SCORES OF 5 "BEST" READERS IN TWO GROUPS OF SPECIALISTS

	Per Cent of False Negative Diagnoses (*i.e.*, misses)	Per Cent of False Positive Diagnoses (*i.e.*, over-reading)
Group A	21 (range 17–23)	0.5 (range .3–.8)
Group B	26 (range 21–30)	0.3 (range .2–.4)

The tentative conclusions after the study were that (a) about one-half of the few cases of active pulmonary tuberculosis in the student body are detected as a result of the entrance survey minifilm, and about one-half as a result of symptomatic disease developing after a negative minifilm; (b) no new cases were discovered by examination of contacts; and (c) an entrance minifilm at time of registration is probably adequate in this type of institution.

COMMENT

In this survey, the interpreters missed about one-third of the roentgenologically positive minifilms, and over-read about 1 per cent of the negative films. Better technique, more careful selection of readers, and dual readings would reduce the number of positives missed by a factor of about one-third. This second reading will increase the number of false positives but, from the public health point of view, the gain of additional contagious cases of tuberculosis would be regarded as justifying this inconvenience. To illustrate the practical aspects of these and similar studies in mass survey work, let us consider a survey of 200,000 adults in this country. At the present time, such a survey is estimated as yielding on the average about 100 true positive cases of active pulmonary tuberculosis (composed of both new cases and previously known cases). A single interpretation of these 200,000 minifilms by experienced readers would result in the detection of about 70 true positives, and the missing of about 30. A second reading of the series will result in the detection of about one-third of these missed cases (or some 10 cases), so that the total yield will be 80 true positives.

The single reader will over-read at least 1.1 per cent of the true negatives, that is about 2,196 out of the 199,800 negatives. A second reading would probably add a proportionate number of false positives, giving a total of about 4,392 false positives, who will be recalled for check-up films and per-

haps other tests. If highly contagious cases of pulmonary disease are detected in the 10 true positives gained by the dual reading, such added recall may be regarded as worth while. (To detect 10 positives in another or fresh group of adults, one would need to photofluorograph about 30,000 persons.)

Stradling and Johnston[22] believe that the number of needless recalls (*i.e.*, the degree of over-reading) can be reduced almost 50 per cent by the use of routine posterior lordotic minifilms in addition to the anterior view; this also decreased their degree of under-reading by a significant amount.

Tuddenham[23] has discussed the value of supervoltage techniques and the use of the minifying lens in the detection of some subliminal soft tissue pulmonary lesions. It is well known that laminagrams also reveal some lesions not visible on the standard roentgenograms. These special techniques are outside the scope of the chief considerations in this paper; they are not used routinely.

Finally, it is to be noted that correct viewing methods are helpful. For maximum acuity, illuminators not in use should be switched off. The illuminators in use should have shutters and a variable intensity dial. Films should be read in a systematic way, *e.g.*, from left to right, and top to bottom. Attention is the first essential.[11]

DISCUSSION

To *behold* is not necessarily to observe. All students of radiology and pathology receive daily reminders of this elementary truth. Its appreciation must stimulate us to better methods of observation and analysis. For this reason, I believe the many studies in this field will have been worth while.

MISSED LESIONS

What types of "lesions" are most often missed?

Are they clinically significant?

Why are they missed by experienced physicians?

Types of Lesions Missed. Miller, Zwerling, Garland and Yerushalmy[11] studied this question in their early investigations. The following summarizes their conclusions, and those of other investigators in this field, when plain anteroposterior chest roentgenograms are used.

The lesions missed included: (a) Those *obscured by bone or soft tissue densities*, for example, densities behind or merging with rib, hilus, heart or diaphragm shadows; (b) those *located at the base* of the lung; (c) those of *small size* (under 1 cm. diameter); (d) those of *faint density*.

At the same time, it is to be noted that opacities as large as 4 cm. in diameter, and cavities almost as big, were also missed by *different* observers—lesions quite visible in retrospect (Fig. 4, *A* and *B*; 5, *A* and *B*; and 6, *A* and *B*).

Significance of Lesions Commonly Missed. Zwerling, Miller, Harkness and Yerushalmy[27] investigated this question and concluded that clinically active lesions are apparently missed just as frequently as inactive ones. Groth-Petersen *et al.*[14] and Moeller of the Danish Tuberculosis Service also reported that the lesions missed on single interpretations of minifilms include many large and clinically significant ones.

Reasons for Missing Lesions. These may be classified as "objective" and "subjective." The objective ones include inadequacy of roentgenographic exposure and processing, inadequacy of viewing arrangements, inexperience or fatigue of interpreter, lack of interest, etc. The subjective ones are of unknown nature: there are times when an experienced physician "sees" a visible lesion clearly and times when he does not. This is the baffling problem, apparently partly visual and partly psychologic. Some densities are doubtless "seen" but not evaluated as significant at the moment; others are just not "seen" at a given reading. Still others are occasionally "seen" where they do not truly exist. These phenomena occur in all clinical and laboratory work that has been studied so far. They constitute the still unexplained "human equation" in diagnostic procedures.

The converse of under-reading is over-

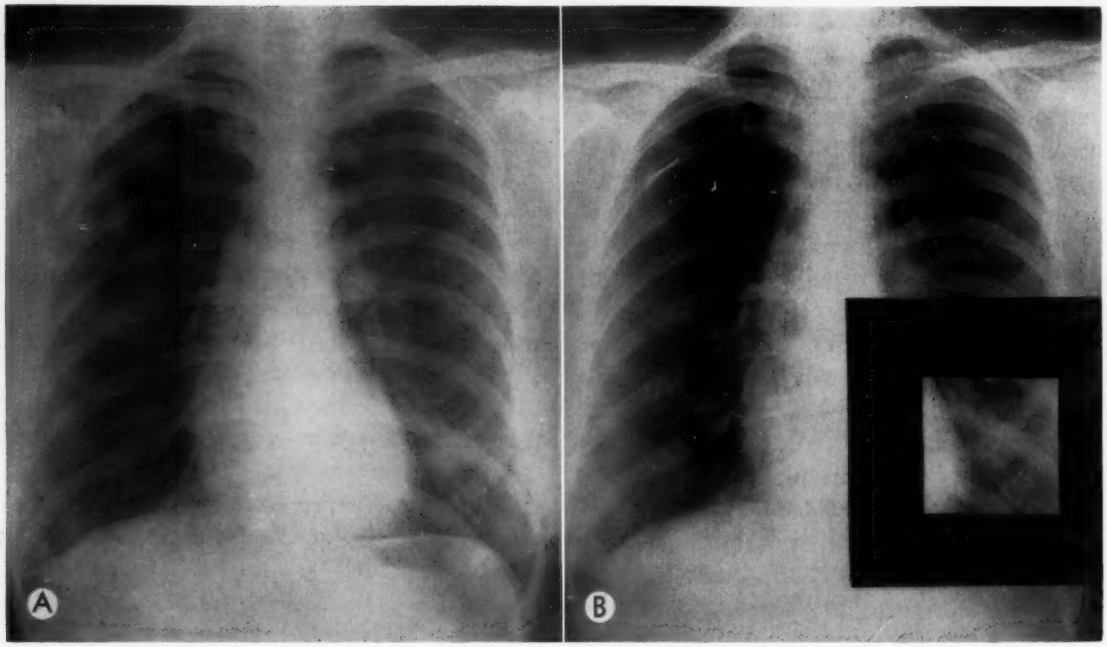

FIG. 4. (*A* and *B*) Example of missed lesion. Female, aged forty, without symptoms. *A* interpreted as negative. Opacity 2.5 cm. in *lower* lung field. This shows more clearly when masked (*B*). Adenocarcinoma.

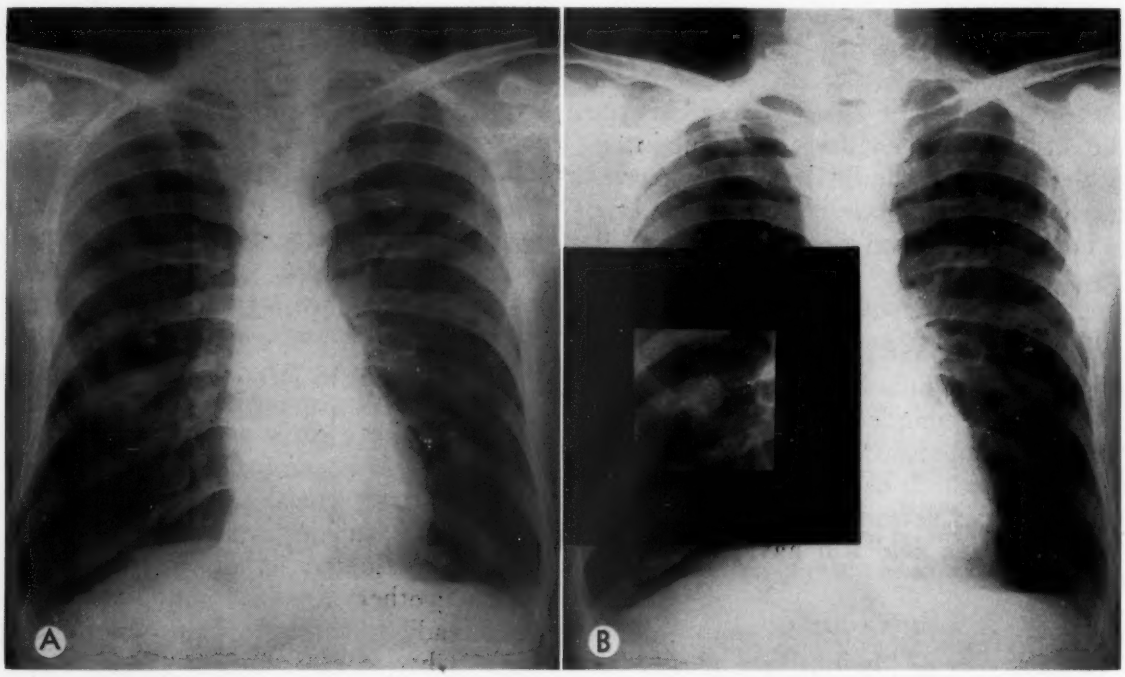

FIG. 5. (*A* and *B*) Example of missed lesion. Male, aged sixty-five, without symptoms. *A* interpreted as negative. Lesion, 2 cm. in diameter, in middle half of right lung, partly *obscured* by rib shadows (*B*). Squamous cell carcinoma.

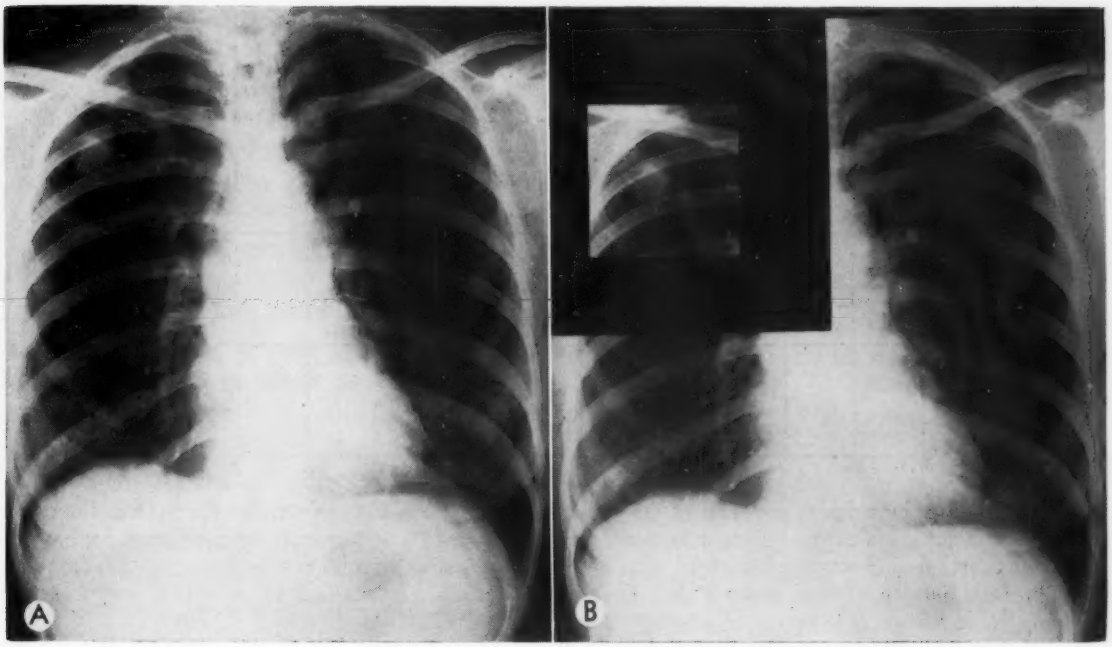

Fig. 6. (*A* and *B*) Example of lesions missed. Female, aged fifty-five, without symptoms. *A* interpreted as negative. *B* shows same case with mask around lesions. Stereoscopic studies disclosed multiple other lesions in this lobe. Clinical and serial studies confirmed the diagnosis of tuberculosis.

interpretation or diagnosis of nonexistent disease. This is due to a series of factors comparable to the above mentioned. Technical and physical elements enter into the problem—such as underexposure, heavy vascular markings, unequal muscle shadows, anomalies and artefacts—and the "human equation." There are times when a reader over-interprets a normal shadow and times when he does not. The ensuing false positive diagnosis may result in as much psychic, physical and economic trauma as a true positive! Domestic, insurance and employment problems mount *pari passu*.[12]

MASS SURVEYS

How have mass surveys in this country proved so useful in the face of this demonstrated degree of observer error, especially in the light of the fact that most surveys have been conducted with untested or inexperienced readers? The answer would appear to be three-fold: (a) There *is* no good evidence that they have been useful, (b) many missed cases of pulmonary disease get well spontaneously, and (c) most over-diagnosed survey cases come to no harm. Tuberculosis mortality has declined as greatly in states without active survey programs as in those with them.

It has been shown in several studies that a minority (as few as one-tenth) of new registered cases of active pulmonary tuberculosis are detected by such surveys, and that in routine hospital admission surveys there are detected on the average only about 30 per cent more cases of active tuberculosis than are discovered by general population surveys (Siegal, Plunkett, and Locke, *J.A.M.A.*, 1955, *157*, 435) (Fig. 7).

Writing about Denmark, Groth-Petersen *et al.*[14] observe "that the cause of the decline of tuberculosis since the eighties is no more known in this country than elsewhere. General improvement in living conditions has probably been crucial. That Denmark already in the thirties was among the nations with the lowest tuberculosis mortality *cannot* be attributed to the fight against bovine tuberculosis, nor the work of chest clinics, nor to BCG vaccination, for the

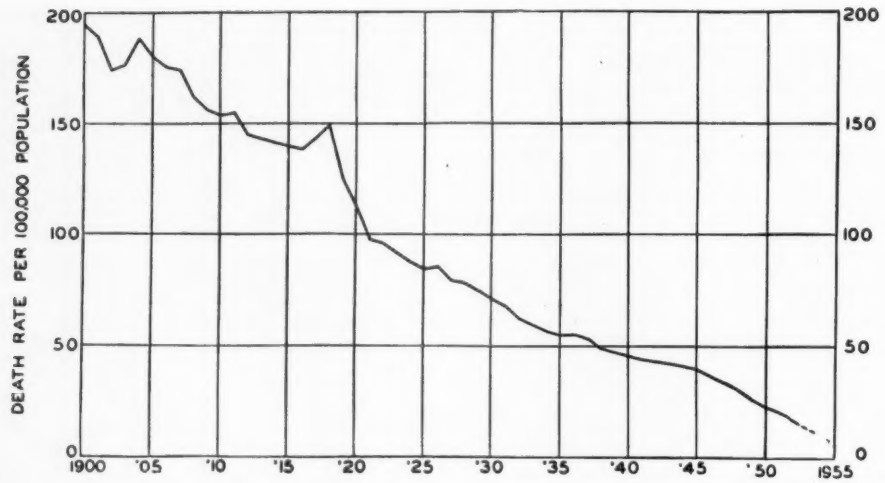

FIG. 7. Decline in tuberculosis death rate in the United States, 1900 to 1955. Note that the slope of the curve since 1937 is not significantly different from the slope between 1921 and 1937. Mass roentgenographic surveys for tuberculosis became widespread after 1937 (reaching over 17 million persons in 1955; Blomquist, Tuberculosis Service, United States Public Health Services). The curve fails to show that they had any demonstrable effect on the rate of tuberculosis mortality decline.

effects of these factors could not have manifested themselves so early." Similar conclusions surely apply in this country.[4]

Incidentally, Groth-Petersen's group was "shocked" to discover that the degree of disagreement of their expert minifilm readers was so great.[14] They excluded all of the films which were regarded as technically inferior (in their test material of 5,000 minifilms), repeated their readings and found that their results were unchanged. To their astonishment, they found that extensive as well as small lesions were missed; indeed, only 5 of the 26 positive cases in their series were classified by Danish standards as minimal.

When we teach these facts to our own residents, we are met at first with incredulity. After describing the limitations of observation in other fields, some residents have become quite distressed, echoing Johnson's student who said "But you can't have the whole world a jelly," or "It's as though my world was cracked open." They dislike thinking that specialists in a given field are not always expert in that field. Perhaps (says Johnson) we should aim to replace the security of thinking along well-defined, familiar channels, with a new kind of security based on the acceptance of ambiguity, uncertainty and open choice.[16,17] Reasonably applied, this should be a scientist's course.

One of my friends, a well known professor of radiology, a few years ago, expressed the hope that we had discontinued our investigations in this field because they were so morale-disturbing. Perhaps he was confusing the nearby shadow with the distant substance. Had he remembered the sentence in Matthew following that used in our prefix he would feel exhorted to "Give not that which is holy to dogs. Neither cast ye your pearls before swine lest perhaps they trample them under their feet. . . . " Radiology has contributed so much to the scientific advancement of medical practice that, it seems to me, it can continue its leadership in studies on the degree of observer error, and on the means for its correction.

SUMMARY

The accuracy of many diagnostic procedures is subject to impairment from errors in technique of examination and interpretation. The former are correctable with care, and the latter partly correctable with training and experience.

However, even experienced physicians are found to have a measurable degree of "observer error," due apparently to the so-called human equation. For example, experienced interpreters of a series of plain chest roentgenograms are apt to miss about 30 per cent of those films positive for roentgenologic evidence of disease, and to over-read about 2 per cent of those negative for disease. Further, in evaluating pairs of serial roentgenograms for alterations in the status of disease, one experienced physician is apt to disagree with another in about one-third of the cases, and (on review) to disagree with himself in one-fifth of them.

Comparable degrees of error occur in many forms of clinical practice. Indeed, if all branches of medicine could be tested, the phenomenon would probably be found quite universal.

Accuracy in diagnosis can be improved by independent examination (dual interpretation) either by the same observer on two different occasions, or by two different observers—without knowledge of the results of the other interpretation. This has been shown to be true for single film examination, and for serial film interpretations.

Realization of the degree of observer error in different fields should provide a stimulus to greater care in examination, to increased use of consultation, and, above all, to continued attempts at elucidation and correction of the factors involved.

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APPENDIX

Dr. R. R. Newell kindly reviewed this essay and commented by quoting former President Hoover: "What do you want, security or self-reliance?" Self-reliance should include an effort to correct one's mistakes and capitalize on one's blunders. The only real security is the power to adapt.

I would add the following suggestions to radiologists and other clinicians: (1) Study the degree of observer error in your own work. (2) Attempt to reduce it by high quality of technical work, dual reading, and periodic conference or consultation with your colleagues.

REFERENCES

1. Bakwin, H. Pseudocia pediatrica. *New England J. Med.*, 1945, *232*, 691–697.
2. Belk, W. P., and Sunderman, F. W. Survey of accuracy of chemical analyses in clinical laboratories. *Am. J. Clin. Path.*, 1947, *17*, 853–861.
3. Birkelo, C. C., Chamberlain, W. E., Phelps, P. S., Schools, P. E., Zacks, D., and Yerushalmy, J. Tuberculosis case finding: Comparison of effectiveness of various roentgenographic and photofluorographic methods. *J.A.M.A.*, 1947, *133*, 359–366.
4. Cochrane, A. L., and Garland, L. H. Observer error in interpretation of chest films: International investigation. *Lancet*, 1952, *2*, 505–509.
5. Davies, L. G. Observer variation in reports on electrocardiograms. *Proc. Brit. Cardiac Soc.* (Abstract). *Brit. Heart J.*, 1956, *18*, 568.
6. Derryberry, M. Reliability of medical judgements on malnutrition. *Pub. Health Rep.*, 1938, *59*, 139–140.
7. Drolet, G. J., and Lowell, A. M. Whither tuberculosis? Statistical review of reports from selected American and European communities. *Dis. Chest*, 1952, *21*, 527–561.
8. Editorial, *Lancet*, 1954, *1*, Jan. 9.
9. Fletcher, C. M. Clinical diagnosis of pulmonary emphysema; experimental study. *Proc. Roy. Soc. Med.*, 1952, *45*, 577–584.
10. Fletcher, C. M. Letter to Editor. *Lancet*, 1954, *1*, 212.
11. Garland, L. H. On scientific evaluation of diagnostic procedures. *Radiology*, 1949, *52*, 309–328.
12. Garland, L. H. On reliability of roentgen survey procedures. Am. J. Roentgenol. & Rad. Therapy, 1950, *64*, 32–41.
13. Garland, L. H., Miller, E. R., Zwerling, H. B., Harkness, J. T., Hinshaw, H. C., Shipman, S. J., and Yerushalmy, J. Studies on value of serial films in estimating progress of pulmonary disease. *Radiology*, 1952, *58*, 161–177.
14. Groth-Petersen, E., Løvgreen, A., and Thillemann, J. On reliability of reading of photofluorograms and value of dual reading. *Acta tuberc. scandinav.*, 1952, *26*, 13–37.
15. Johnson, M. L. Seeing's believing. New Biology. Penguin Books, London, 1953, No. 15, p. 60.

16. JOHNSON, M. L. Course on factors influencing scientific judgment. *J. M. Educ.*, 1955, *30*, 391–397.
17. JOHNSON, M. L. Observer error; its bearing on teaching. *Lancet*, 1955, *2*, 422–424.
18. MAGATH, T. B., BERKSON, J., and HURN, M. Error of determination of erythrocyte counts. *Am. J. Clin. Path.*, 1936, *6*, 568–579.
19. MILLER, E. R., LINDSAY, S., and DAILEY, M. E. Studies with radioiodine. V. Validity of histologic determination of I^{131} radiation changes in thyroid gland. *Radiology*, 1955, *65*, 384–393.
20. NEWELL, R. R., CHAMBERLAIN, W. E., and RIGLER, L. Descriptive classification of pulmonary shadows. Revelation of unreliability in roentgenographic diagnosis of tuberculosis. *Am. Rev. Tuberc.*, 1954, *69*, 566–584.
21. PATON, B. C. The accuracy of diagnosis of myocardial infarction. A clinicopathologic study. *Am. J. Med.*, 1957, *23*, 761–768.
22. STRADLING, P., and JOHNSTON, R. N. Reducing observer error in 70-mm. chest-radiography service for general practitioners. *Lancet*, 1955, *1*, 1247–1250.
23. TUDDENHAM, W. J. Visual physiology of roentgen diagnosis. A. Basic concepts. AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED., 1957, *78*, 116–123.
24. YERUSHALMY, J. Reliability of chest radiography in diagnosis of pulmonary lesions. *Am. J. Surg.*, 1955, *89*, 231–240.
25. YERUSHALMY, J. Reliability of chest radiography. In: Bronchopulmonary Disease. Naclerio, E. A., Editor. Paul B. Hoeber, Inc., New York, 1957.
26. YERUSHALMY, J., HARKNESS, J. T., COPE, J. H., and KENNEDY, B. R. Role of dual reading in mass radiography. *Am. Rev. Tuberc.*, 1950, *61*, 443–464.
27. ZWERLING, H. B., MILLER, E. R., HARKNESS, J. T., and YERUSHALMY, J. Clinical importance of lesions undetected in mass radiographic survey of chest. *Am. Rev. Tuberc.*, 1951, *64*, 249–255.

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BODY SECTION ROENTGENOGRAPHY IN THE EVALUATION AND DIFFERENTIATION OF CHRONIC HYPERTROPHIC EMPHYSEMA AND ASTHMA*

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IT HAS been recognized by many authors that both the clinical and roentgenologic diagnosis of established pulmonary emphysema presents many difficulties. There is general agreement that roentgenologic changes produced by pulmonary emphysema are far from specific, a number of studies having shown that there is a poor certainty of making a correct diagnosis on the basis of plain roentgenograms of the chest. In the study reported by Knott and Christie,[21] errors were made in the differentiation between patients with established emphysema and normal subjects of the same age. Whitfield and his colleagues,[31] as a result of a more extensive study of the same problem, arrived at the conclusion that while roentgenologic investigation might provide evidence suggestive of the presence of emphysema, it gives a less accurate assessment of severity than is possible from clinical examination and pulmonary function tests. They showed in addition that a number of the customarily accepted roentgenologic signs of emphysema are quite misleading.

The results of such investigations might apply equally well to spasmodic asthma, and, although no study has yet been reported in this regard, it becomes immediately obvious that differentiation of these two diseases by roentgenologic means must be subject to great error. Both fluoroscopically and roentgenographically, hypertranslucent lung fields, a large volume thorax and a low diaphragm of reduced respiratory excursion are all signs common to these two diseases, but here their similarities cease. The relentless progress of degeneration in hypertrophic emphysema contrasts sharply with the comparative benignity of bronchospasm in asthma, but their roentgenologic mimicry supplies us with little evidence of the important differences between them.

Recent pathologic investigations, using greatly improved techniques for studying the lungs, have emphasized two points in relation to these two diseases. The first, stressed by Gough,[17] is that it is not uncommon to see pathologically normal lungs in patients who have had spasmodic asthma of considerable severity for many years. The second observation, made by McLean,[24] is that the early pathologic changes of centrilobular emphysema can be shown to be present in the majority of men over the age of fifty.

The very considerable volume of work in the last ten years by investigators attempting to measure pulmonary performance has added a number of other observations on this general theme. It has been established that both asthma and emphysema cause severe ventilatory impairment of an obstructive type, which in spasmodic asthma is reversible but which in emphysema is usually not capable of being much modified by treatment. Campbell, Martin and Riley[12] have recently shown, however, that the pattern of air-flow derangement is different in these two conditions. In addition, preliminary observations on the rate of gas diffusion across the lung in emphysema and asthma suggest that this may be a useful technique in their differentiation.[5] Wil-

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liams[32] has shown that the two conditions are sharply contrasted by a difference in diffusing capacity on exercise, the maintenance of normal values in asthma indicating the preservation of a normal pulmonary parenchyma in that condition. In a long term study of 59 patients with emphysema, reported by Bates, Knott and Christie,[9] 2 patients were included in the group although the rate of gas diffusion was initially normal. The follow-up on these 2 subjects showed clearly that they had been wrongly selected, and in fact were middle aged men with the rather sudden onset of bronchospasm; it seemed clear that they did not have established pulmonary emphysema when first seen.

If it can be taken in general terms that the main difference between these two conditions is the destruction of lung parenchyma and bronchiolar obliteration described by Gough and McLean pathologically as characteristic of emphysema, contrasted with the potentially reversible nature of the bronchial changes in spasmodic asthma, then it might be expected that roentgenologic techniques designed to show changes in lung structure and vascularity would differentiate between them. Schoenmackers and Vieten[27] have demonstrated a difference in pulmonary vascularity in patients who have succumbed to these two diseases by postmortem contrast injection of the pulmonary arterial tree. They found a marked obliteration of pulmonary vessels in emphysema in contrast to the normal vascular caliber in patients who had died of asthma. Hornykiewytsch and Stender[19] carried these studies a stage further by making a detailed analysis of the pulmonary vasculature as seen on body section roentgenograms of the lungs, and have reported that the difference between pulmonary emphysema and bronchial asthma roentgenologically is to be seen most characteristically in the changes that appear in the pulmonary arteries. They reiterated a point previously made by Golden[16] and stressed by Barden and Comroe[4] that hyperinflation from any cause produces splaying and alteration in the angles of bifurcation of the pulmonary arterial tree. In asthma, however, arterial caliber is normal, whereas in emphysema the medium and smaller branches of the pulmonary artery have in many segments disappeared. (This study by Hornykiewytsch and Stender was an extension of a most exhaustive investigation into the anatomy of the arterial and venous systems of the lungs as seen by body section roentgenography. Their report comprises a series of ten articles[19] which are strongly recommended as further reading for those interested in the subject.)

Deficiency of the peripheral vasculature of the lungs has been stressed by Barden,[3] Abbott *et al.*[1] and Simon[28] as highly suggestive evidence for the presence of emphysema. Similarly, Stender[29] and Rigler[26] have referred to the obliteration of peripheral vessels as characteristic of the late stages of pulmonary arteriolar sclerosis. On plain roentgenographic evidence alone, however, it is very doubtful if one could consistently appreciate such changes with any conviction except when narrowing is marked and the pathologic process correspondingly advanced (Fig. 1 and 2).

In view of the confused nature of this field as a whole, it was felt worthwhile to study a group of patients suffering from these diseases, both by means of pulmonary function tests and body section roentgenography. The results suggest that the differentiation made on the basis of study of the pulmonary vessels laminagraphically agrees well with the assessment by pulmonary function tests and may generally be regarded as providing a useful additional method for the study of unusual cases of chronic lung disease.

METHODS

I. PULMONARY FUNCTION TESTS

The basic techniques used in the performance of these tests have been described elsewhere, but a few additional details are required for clarification:

(a) *Measurement of Forced Expiration*

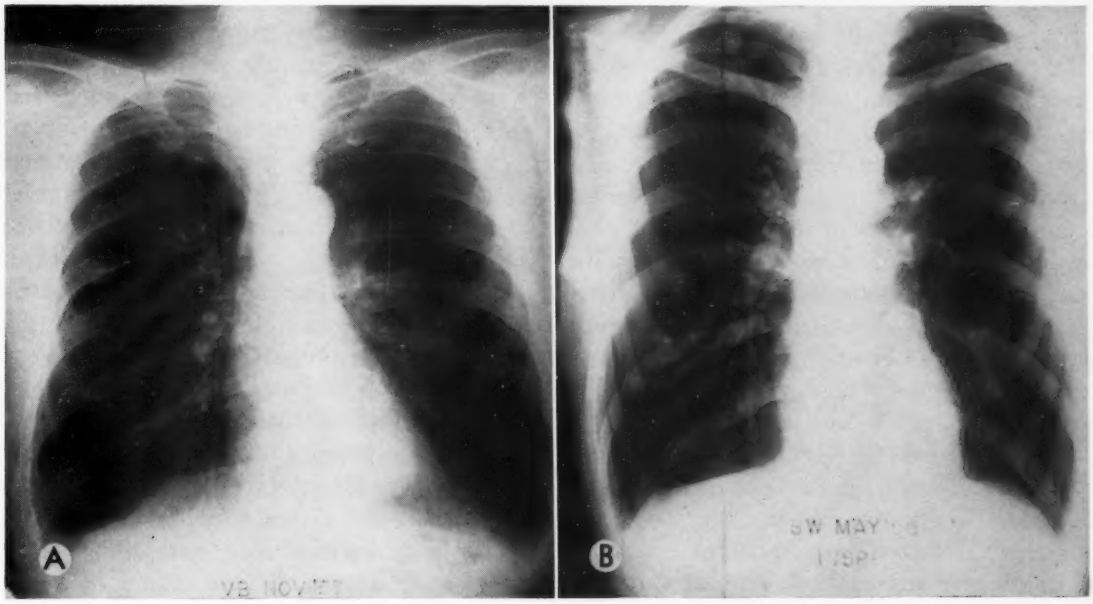


Fig. 1. (*A* and *B*) Posteroanterior roentgenograms of the chest of 2 patients included in the present study. One has severe incapacitating emphysema (Case 3, Table 1) and the other long standing spasmodic asthma (Case 27, Table 11). There is little difference in the appearance of the two chests, the lateral projections (not reproduced) showing evidence of severe air-trapping in both. The state of the peripheral vasculature as visualized supplies no clue as to differentiation. Compare with Figure 2.

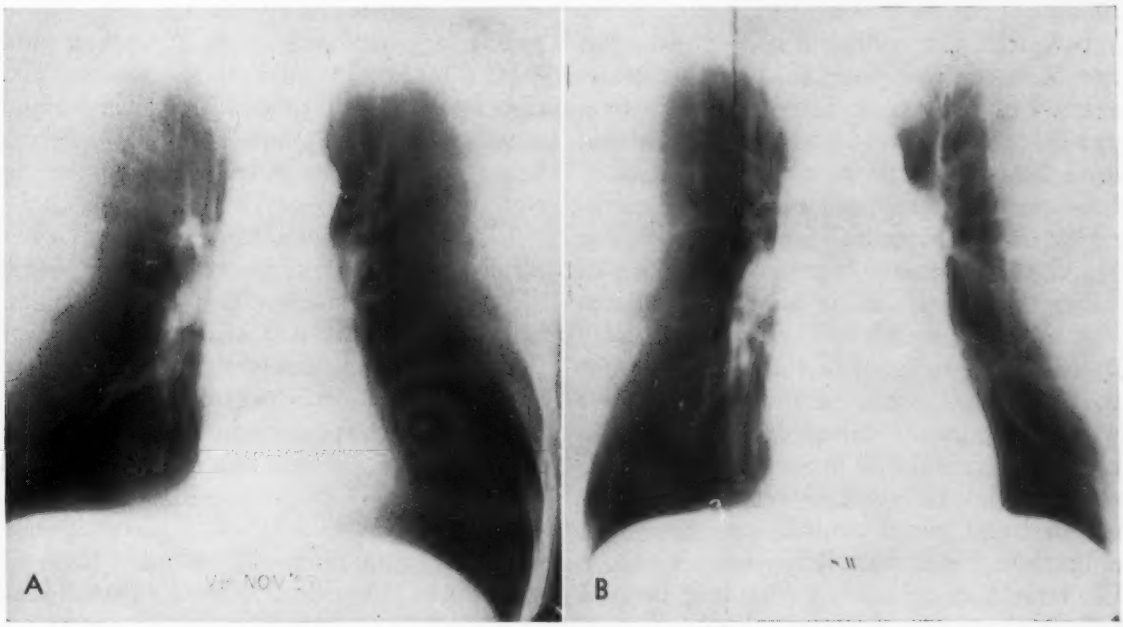


Fig. 2. (*A* and *B*) Body section roentgenograms of the 2 patients illustrated in Figure 1. The extreme narrowing and obliteration of the peripheral arteries in *A* contrast sharply with the normal tapering of the vessels in *B*. In Figures 1 and 2, the patient illustrated in *A* has severe emphysema; in *B* spasmodic asthma. See Figure 13.

and Maximal Midexpiratory Flow Rate. Observations of four separate single maximal expirations were made on each patient, and the result recorded was the highest value obtained. The indirect maximal ventilatory volume (MVV) has been calculated from the volume of gas expired in the first three quarters of a second multiplied by 40 (EFR^{40}). The spirometer used has been specially constructed for this purpose and has a minimal internal tube diameter of 2 inches. It has been shown to respond accurately to flow rates of up to 7 L/sec. The maximal midexpiratory flow rate has been calculated from these tracings by the technique described by Leuallen and Fowler.[22] The kymograph speed on these estimates was greater than that used by these authors and was customarily 7.8 or 3.15 cm./sec. for the more normal subjects, and 0.9 cm./sec. for those with expiratory delay.

(b) *The Subdivisions of Lung Volume and the Helium Mixing Efficiency.* These have been measured on the helium closed circuit previously described.[8] In spite of modifications to the helium mixing index subsequently recommended,[10,15] this has not been changed from that originally described since comparative values were available with this index which would not have been available on modifications of it. It is clear that the index loses some sensitivity due to variation in the dead space/tidal volume ratio between subjects. All subjects were studied in a sitting position.

(c) *Measurement of CO Diffusing Capacity.* The circuit used for this estimate is basically that previously described,[6] but with a number of improvements. The CO uptake is calculated by measuring accurately the minute volume respired and the inspired and mixed expired concentrations of carbon monoxide. The mean alveolar CO tension is calculated from a measured end tidal sample of 20 cc. taken automatically from just beyond the expiratory valve during each subsequent inspiration. Normal values with this technique at rest show that the calculated diffusing capacity varies from 12 cc. CO/min./mm./Hg to 25 cc. CO/min./mm./Hg.[7] In patients with established emphysema this value is much lower, but in spasmodic asthma the normal values are preserved as reported previously.[5] The use of an end tidal sample in this type of calculation has recently been criticized by Marshall,[23] who showed that the end tidal sample in emphysema could not be regarded as representative of alveolar gas. However, the single breath method of measuring the pulmonary diffusing capacity which he advocated is also open to serious objection in this condition, since it has not been demonstrated that the rate of CO uptake is correctly measured by this technique.* The alternative of using the measured arterial CO_2 tension to calculate the mean alveolar CO concentration, as devised by Filley *et al.*[14] is not generally suitable for routine use, but Williams,[32] using this technique of calculating the mean alveolar CO from the arterial CO_2 tension, finds that the pulmonary diffusing capacity so calculated sharply differentiates between emphysema and asthma. In the present stage of knowledge, the finding of a normal pulmonary diffusing capacity using end tidal sampling may be taken as strong evidence against the presence of established emphysema, and the selection of patients has accordingly been based on this criterion.

(d) *Measurement of Arterial Blood Gases.* Arterial samples have been drawn in some of these patients, using a Riley needle. Subsequent analysis of the blood has been carried out by means of the Nahas cuvette and Beckman DU spectrophotometer for arterial oxygen saturation,[25] and by the Astrup apparatus and Radiometer pH meter for the pCO_2.[2]

(e) *Criticism of Methods.* The objections to the end tidal diffusing capacity measurements are mentioned above. The closed

* It seems clear that it must be in error, since the concentration differences of CO are multiplied by the lung volume determined separately on a helium closed circuit. But the lung volume calculated from the single breath helium dilution ratio in emphysema is not uncommonly less than half of this volume; hence, the gas concentration differences are being multiplied by a falsely high volume.

circuit method of measuring the subdivisions of pulmonary volume is very satisfactory and does not give rise to serious error. The small correction for helium absorption suggested by Birath and Swenson[11] has not been made in these cases. The measurement of a single expiration in place of the older fifteen second or thirty second maximal breathing capacity might be criticized, but in our experience is very much simpler, and a great deal easier for the patient to perform. It is not likely that there is a serious discrepancy between the results with the two techniques. The measurement of the maximal midexpiratory flow rate as proposed by Leuallen and Fowler[22] seems a useful addition to the test, and there is some evidence from the results obtained that it is a more sensitive measurement of bronchospasm than the indirectly calculated MVV. The analysis of arterial blood samples for arterial saturation using the Nahas cuvette and the Beckman DU spectrophotometer has proved extremely reliable and comparisons with the Van Slyke estimates show no deviations greater than 1.2 per cent. Similarly, the arterial pCO_2 calculated from the Astrup procedure has been within a few millimeters of that calculated by Van Slyke determination and pH measurement.

2. ROENTGENOLOGIC EVALUATION

(a) *Roentgenographic Techniques.* Plain roentgenograms of the chest were first made on all patients in posteroanterior and lateral projection, both in deep inspiration. In only a few cases were inspiratory and expiratory roentgenograms obtained, and then only at the specific request of the referring physician. Despite the well established value of such a procedure in the identification of decreased diaphragmatic excursion and other signs of air-trapping, we did not regard this aspect of the problem as particularly relevant to the present investigation, nor have we been convinced that appreciation of these changes is of much value in the differentiation of emphysema and asthma.

Fig. 3. Body section roentgenogram in the supine position, anteroposterior projection, of a healthy thirty-three year old man without respiratory symptoms or abnormalities of pulmonary function. A normal tapering of the arteries of both lungs is demonstrated. In Figures 6, 9, 12, 13, 16, 20 and 23, the right lung field of this laminagram is LogEtronically reproduced for comparison with the LogEtronic print of the patient being illustrated.

The technique of body section roentgenography varied little once the desired levels in the chest had been established. With few exceptions, examinations were performed in the supine position, in anteroposterior projection, with respiration held in quiet inspiration. Roentgenographic techniques have varied considerably, but perhaps the most satisfactory results have been obtained by the methods described by Kane.[20] Early in the investigation, four laminagrams were made in the coronal plane at 1 cm. intervals: one in the midline, one anterior, and two posterior to the midline. By experience it has been found necessary to obtain only two laminagrams, one midline and one 2 cm. posterior to the midline. Consistenly good visualization of the upper and lower lobe arteries and veins has been obtained with these two laminagrams (Fig. 3), but *the absolute necessity for at least two sections has been demonstrated repeatedly.* Not infrequently, one section will cut through

arteries running an oblique course, thus creating the impression of an abrupt narrowing of their lumina, whereas the section made at 2 cm. distance will reveal the true caliber of the vessels.

It was appreciated that vessel caliber might be influenced both by posture and by chance variations in intrapleural pressure when the exposure was made. Several patients were accordingly examined in the upright position in quiet inspiration, in the supine position performing the Valsalva procedure at a measured intra-alveolar pressure of about +80 cm. of water, and during a modified Müller procedure with a pressure of about −40 cm. of water. In spite of Westermark's observations,[30] no appreciable alteration in vessel size was discernible as a result of these variations, so that the supine position in quiet inspiration was used as a routine for all subsequent examinations. Laminagrams made in lateral projection on a few patients have not been found to give information not available from the anteroposterior studies, and have not been continued.

(b) *Methods of Roentgenologic Evaluation.* In all patients, the plain roentgenograms and the body section roentgenograms have been the subject of three separate assessments by one of the authors (R.G.F.). Each assessment was made on an entirely objective basis, without knowledge of the patient's name, clinical history, results of pulmonary function tests, or of the diagnosis made on any previous evaluation. The three assessments included a statement of opinion regarding each of the changes described below, ending with a definite statement as to whether hypertrophic emphysema was present or not.

Plain Roentgenograms of the Chest. In each case before viewing the body section roentgenograms, the plain roentgenograms of the chest were evaluated objectively and an opinion recorded regarding the following points:

(1) The presence and severity of air-trapping was noted, as judged chiefly by the signs of low diaphragmatic position, lung field hypertranslucency, increase in retrosternal air space, and smallness of the heart shadow.

(2) The presence of any changes which would suggest that hypertrophic emphysema rather than simple bronchospasm was responsible for the signs of air-trapping. Special attention was paid to evidence indicating a decrease in the caliber of the peripheral vasculature and if this change was discernible, its localization was noted. In addition, Whitfield and his associates[31] have suggested that the more marked the kyphotic curvature, the greater the likelihood of a nonasthmatic etiology; conversely they suggest that hypertranslucency localized to the lower lung fields is more likely to be found in asthma and bronchospasm, and these changes were noted if present.

(3) Cardiac enlargement was naturally of great importance as evidence of cor pulmonale, especially if associated with an increased caliber of the hilar arteries and a discrepancy between the hilar and peripheral arterial size.

Body Section Roentgenograms. After recording the opinion from the plain roentgenograms, the body section roentgenograms were analyzed in the following manner:

(1) The third, fourth and fifth stage branches of the pulmonary artery were followed toward the periphery of the lungs and the rapidity with which their caliber decreased was noted. Any deviation from normal tapering was regarded as being of possible significance, a number of normal controls of different age groups being used as a baseline for comparison. Although the arteries of both lungs were assessed in this manner, those of the right lung were more easily appraised because of partial obscuration by the heart of the lower lobe vessels on the left.

(2) The localization of peripheral arterial narrowing was recorded, usually on a topographic rather than an anatomic basis. The difficulty of establishing lobar limits on single plane body section roentgeno-

grams prevented more exact localization beyond stating predominant lower lung, upper lung, or generalized involvement.

(c) *Criteria for Roentgenologic Diagnosis of Hypertrophic Emphysema.* On the basis of the above observations and those reported by Hornykiewytsch and Stender,[19] a rapid decrease in caliber and disappearance of the peripheral pulmonary artery branches near their third and fourth stage divisions were regarded as the most important single criterion for diagnosis (Fig. 2, 5, 6, 8, 9, 11 and 12). As would be expected, the more extreme the arterial tapering, the more evident was the avascularity on the body section roentgenograms. Localization of vessel changes was of some assistance since normally vascularized upper lung fields contrasted sharply with deficient lower lung fields and made appreciation of the latter more obvious (Fig. 8 and 11). Alteration in caliber of the veins has been noted but has not been of great help in assessment, since its exact significance is not as yet completely understood.

RESULTS

The results are shown graphically in Tables I, II, and III. The patients have been divided into three groups: (1) Patients who on clinical and function test criteria had established pulmonary emphysema; (2) patients who from a clinical history of periods of freedom from dyspnea and from the finding of a normal resting pulmonary diffusing capacity were considered to be suffering from spasmodic asthma without pulmonary emphysema; and (3) special problem cases in which unusual findings prevented their inclusion in groups 1 or 2.

1. PULMONARY EMPHYSEMA

Table 1 shows the general characteristics of the 26 patients included in the pulmonary emphysema group. The general increase in resting lung volume (column 5)

TABLE I

CHRONIC PULMONARY EMPHYSEMA

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
No.	Case	Sex	Age	VC	FRC	ME %	MVV L/ min.	MM FR L/ sec.	Dco	Arterial		Plain Film Assessment			Lamina-graphic Assessment			Distribution
										O_2Hb Sat.	pCO_2	Air-trapping	Emphy-sema	Heart	1	2	3	
1	R.A.	M	54	2.7	5.0	34	27	0.3	9.9	—	—	+++	Susp.	N	E	E	E	L>U
2	M.B.	M	65	2.0	3.3	35	21	0.4	7.7	—	—	+	Susp.	N	E	E	E	L>U
3	V.B.	M	60	1.7	5.5	49	18	0.3	8.1	—	—	+++	o	N	E	E	E	L>U
4*	L.B.	M	51	1.9	—	—	—	—	6.5	82	78	+++	o	CP	E	E	E	L>U
5	E.B.	M	62	2.1	3.2	28	30	0.3	5.9	—	—	+++	Susp.	N	E	E	E	Gen.
6	X.B.	M	59	2.8	3.5	49	60	1.2	9.4	—	—	+	o	N	E	E	E	Gen.
7*	E.C.	F	59	1.2	3.3	23	19	0.3	5.2/6.4	82	65	+	o	N	E	E	E	L>U
8	A.E.	M	65	1.6	5.5	41	10	0.1	6.1	—	—	+++	o	N	E	E	E	Gen.
9†	C.F.	M	54	1.6	5.6	30	13	0.2	5.6/7.2	96	41	+++	o	N	E	E	E	Gen. except LUL normal
10†	L.F.	M	55	1.9	3.9	30	16	0.2	6.9	—	—	+++	Susp.	N	E	E	E	Gen.
11	J.F.	M	64	1.7	4.1	43	17	0.5	5.4	—	—	++	o	N	E	E	E	Gen.
12	G.L.	F	49	0.7	4.1	16	12	0.2	4.7/6.8	89	58	+++	Susp.	N	E	E	E	U>L
13	A.L.	M	67	2.4	5.1	32	38	0.6	7.4	—	—	+++	o	N	E	E	E	Gen.
14	W.McG	M	65	2.2	3.7	33	28	0.4	11.7	—	—	—	—	—	E	E	E	Rt.>Lt
15*	J.M.	M	54	1.7	2.4	43	16	0.2	4.6/7.2	50	72	o	o	N	E	E	E	L>U
16	N.R.	M	48	2.3	4.1	33	23	0.6	6.8/9.2	98	42	+++	Susp.	N	E	E	E	L>U
17	A.R.	M	53	2.0	6.6	36	20	0.3	4.9/8.9	82	52	+++	o	N	E	E	E	Gen.
18	C.R.	M	48	2.3	6.4	24	27	0.3	7.5	—	—	—	—	—	E	N	E	L>U
19*	W.S.	M	57	1.8	4.0	37	27	0.3	10.2	86	50	+++	o	CP	E	E	E	Gen.
20	P.T.	M	52	1.7	5.3	50	13	0.2	8.5	90	54	+++	Susp.	N	E	E	E	Gen.
21*	L.V.	M	44	1.8	3.7	30	26	—	7.4/9.5	87	57	+	o	CP	E	E	E	L>U
22	L.B.	F	44	1.3	2.6	22	13	0.2	4.6/6.2	90	42	+++	o	N	E	E	E	Gen.
23	T.B.	M	64	1.2	4.8	31	12	0.2	4.5	—	—	+++	Susp.	N	N	N	E	Equivocal
24	E.R.	M	51	1.7	4.9	53	25	0.4	9.6	—	—	++	o	N	N	E	E	L>U
25	R.LaB	M	51	1.9	3.3	28	27	0.4	8.9	—	—	o	o	N	N	N	D	—
26	J.LaF	F	64	1.2	3.2	37	12	0.2	8.9	—	—	+++	o	N	N	N	D	—

Key to abbreviations: Column 4, vital capacity; Column 5, functional residual capacity; Column 6, helium mixing efficiency percentage (see Reference 16); Column 7, maximal ventilatory volume, calculated from the three quarters of a second forced expiratory volume times 40; Column 8, maximal midexpiratory flow rate (see Reference 15); Column 9, Dco—steady state diffusing capacity, calculated from end tidal sample, and, where a second figure is given, this is calculated from the measured arterial pCO_2 (see Reference 22); Column 12, +++ advanced, ++ moderate, + mild; Column 13, Susp.—suspicious or suggestive; Column 14, CP—cor pulmonale. N—Normal; Columns 15 to 17, E, emphysema. D, doubtful. N, normal. The assessments by R.G.F. in Columns 15, 16 and 17 were made without knowledge of the previously recorded opinion; Column 18, L, lower lung fields. U, upper lung fields. Gen., generalized.

* These patients were in clinical right ventricular failure at the time of study.

† These two men were brothers.

Table II

SPASMODIC ASTHMA

No.	Case	Sex	Age	VC	FRC	ME %	MVV L./ min.	MM FR L./ sec.	Dco	Plain Film Assessment			Laminagraphic Assessment			Clinical Comment
										Air-trapping	Emphysema	Heart	1	2	3	
27	S.W.	M	25	3.4	5.4	24	13	0.2	26.0	+++	o	N	N	N	N	
28	P.D.	M	49	4.8	3.6	50	94	1.3	26.3	++	o	N	N	N	N	
29	K.C.	F	32	2.7	3.1	41	41	1.2	22.0	+	o	N	N	N	N	
30	P.D.	F	14	3.5	2.6	31	76	1.7	12.6	o	o	N	N	N	N	
31	J.D.	M	65	2.4	3.6	58	44	0.5	12.7	++	Susp.	N	N	N	N	
32	F.E.	M	25	3.9	3.9	40	133	3.8	21.9	+++	o	N	N	N	N	
33	L.L.	M	38	3.1	1.7	50	91	3.2	10.3	o	o	N	N	N	N	
34	A.O.	M	44	3.4	4.0	34	66	—	11.3	++	o	N	N	N	N	presteroid treatment
				4.3	3.3	58	122	4.3	19.6							poststeroid treatment
35	D.P.	M	35	3.2	3.6	66	46	0.5	17.9	++	o	N	N	N	D	
36	S.S.	F	33	1.5	1.9	52	56	1.1	13.1	—	—	—	N	N	N	
37	T.S.	M	24	2.6	3.2	15	28	0.4	10.1	o	o	N	N	N	N	presteroid treatment
				5.4	4.4	68	176	5.6	25.6							poststeroid treatment

Column heading abbreviations same as in Table I.
In Case 34 and 37, the two sets of results refer to those obtained before and after treatment.

Table III

SPECIAL CASES

No.	Case	Sex	Age	VC	FRC	ME %	MVV L./ min.	MM FR L./ sec.	Dco	Plain Film Assessment			Laminagraphic Assessment			Clinical Comment
										Air-trapping	Emphysema	Heart	1	2	3	
38	N.B.	F	—	—	—	—	23	— 0.4		+++	Susp.	N	E	E	E	Clinically spasmodic asthma. Low MVV observed during attack. Minimal dyspnea when not in attack
			54	2.1	2.4	62	62	1.5	16.5							
39	G.E.	M	55	2.7	3.1	59	70	1.8	25.8	+	o	N	E	E	E	Obese. Chronic bronchitis and bronchospasm. E.C.G. normal
40	R.P.	M	40	4.1	4.3	70	76	1.1	22.6	+++	Susp.	N	N	D	D	Chronic bronchitis and slight spasm. Dyspnea slight
41	W.H.	M	65	3.5	4.5	58	76	1.5	Rest 5.9 / Exer. 6.8/7.7	Diffuse reticulation	o	N	N	N	N	O_2Hb 95%, pCO_2 32 mm.Hg, Hb 110%. Five year progressive dyspnea without cough. Final diagnosis pulmonary infiltration of unknown cause
42	B.F.	F	42	2.3	2.0	39	64	3.8	15.7	o	o	N	N	N	N	O_2Hb 77%, pCO_2 52 mm.Hg. Gross obesity and alveolar hypoventilation syndrome
43	T.F.	M	55	2.7	4.5	48	52	0.9	Rest 9.8 / Exer. 18.7	++	o	N	N	D	D	Selected as "old normal" subject. Dco at this exercise 26.4 ± 3.2 in normal group *Note:* FRC ↑ : MMF ↓ ? Early emphysema

Column heading abbreviations same as in Table I.
See Text for discussion of the individual results in this group.

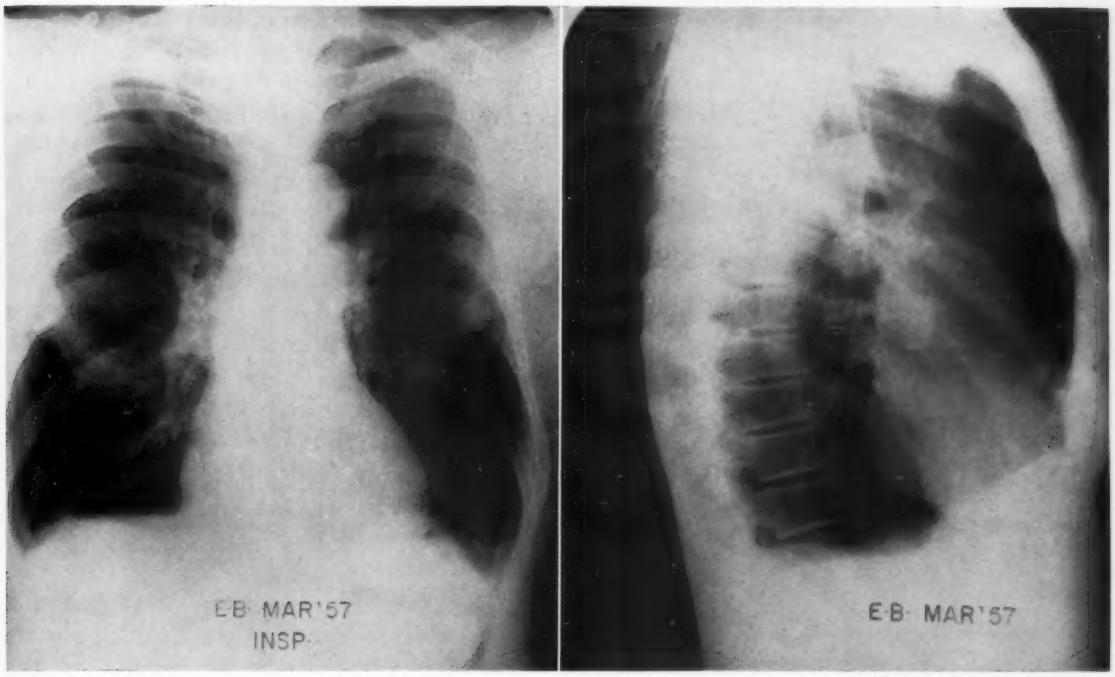


Fig. 4. Case 5, Table 1. Pulmonary emphysema in a sixty-two year old man with a history of chronic cough for more than fifteen years, and progressive dyspnea for the past three years. Physical signs of generalized rhonchi and reduced breath sounds. No evidence of right heart failure. Posteroanterior and lateral roentgenograms of the chest reveal hypertranslucent lungs of somewhat greater volume than normal, a low flat diaphragm and increased retrosternal air space. There is suggestive evidence of deficiency of the arterial tree in the lower half of each lung.

and gross ventilatory defects (columns 7 and 8) present in this group are both evident. The resting Dco is very low (column 9), and these low figures are confirmed in some cases by the resting Dco calculated using the arterial pCO_2 as an alternative procedure (column 9). Of the 11 patients in whom the arterial blood was studied, significant CO_2 retention was present in 8. Clinically evident right ventricular failure was present in 5.

Reference to columns 12, 13, and 14 in Table 1 will show that from evaluation of the plain roentgenograms of the chest by R.G.F. on the 24 patients on whom roentgenograms were available, signs of air-trapping were present in all but one, and were severe in 16 (Fig. 4). In only 8 of the 24 were changes noted which suggested that hypertrophic emphysema might be present (column 13); on review of these cases in conjunction with the laminagrams, it became apparent that reliance was being placed chiefly on evidence of peripheral arterial narrowing as assessed on the plain roentgenograms (Fig. 4, 7 and 10). We were not able to confirm Whitfield and coworkers' concepts of the value of the degree of kyphotic curvature and relative basal translucency as differential points between emphysema and spasmodic asthma. It is interesting to note that of the 8 patients showing evidence suggesting emphysema on the plain roentgenograms, the degree of air-trapping was severe in all but one (Case 2). In 3 additional patients (Case 4, 19 and 21), definite cardiac enlargement was sufficiently characteristic in contour to be labelled cor pulmonale, but in none of these was peripheral arterial narrowing particularly remarkable on the plain roentgenograms. It will be seen that all of these 3 patients were in clinical right ventricular failure.

In summary, therefore, out of 24 patients with established emphysema, plain roentgenograms of the chest suggested the

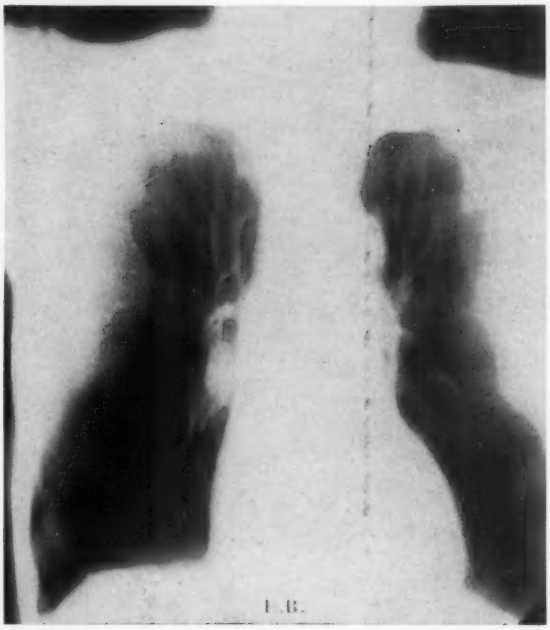


FIG. 5. Same case as in Figure 4. Body section roentgenogram made in the supine position, anteroposterior projection. A deficiency of peripheral vasculature suspected on the plain roentgenograms is confirmed, but is seen to be generalized although more marked in the lower half of each lung than in the upper half. The arterial narrowing begins near the origin of the third or fourth division of the pulmonary arteries. Compare with Figure 3.

diagnosis in 8 because of peripheral arterial deficiency and severe air-trapping, and in an additional 3 because of cor pulmonale. In the remainder, two or more of these signs were absent. It is worth noting that in at least 2 patients (Case 7 and 15), the plain roentgenograms were almost completely normal despite the presence of advanced emphysema on clinical and physiologic criteria.

Reference to columns 15, 16, and 17 in Table I, in which the interpretation of the body section roentgenograms is recorded, shows that R.G.F. made a consistent diagnosis of emphysema on 21 of the 26 patients on each of three separate assessments. In 2 patients (Case 18 and 24), one assessment was normal, and in the remainder the evaluations were split between normal and doubtful.

Analysis of the predominant distribution of the emphysema from body section roentgenograms (column 18) reveals that 10 patients were considered to show generalized changes, and in 10 others the lower lobes were thought to be chiefly involved. It is interesting to note that signs of air trapping were consistently more severe in those patients with generalized involvement than in those with predominant lower lung field involvement. In one patient (Case 12) the upper lobes were clearly mainly affected, while in another (Case 14) the emphasis appeared to be chiefly on the right lung as opposed to the left. In one patient (Case 9) the vascularity of the left upper lobe only appeared to be still normal.

2. SPASMODIC ASTHMA

The results in this group of 11 patients are shown in Table II. As mentioned above, these patients have been selected on the basis of a clinical diagnosis of spasmodic asthma, with periods free from dyspnea. In addition the resting diffusing capacity was in every case normal or nearly so. In 2 of the patients (Case 34 and 37), the function tests were performed both before and after relief of the bronchospasm, and the considerable change in these patients reflects the fact that their condition is potentially reversible. In Case 37, the disappearance of the bronchospasm is clearly revealed by the change in maximal ventilatory volume from 28 L/min. to 176 L/min.

R.G.F. considered that the plain roentgenograms on one patient (Case 31) suggested emphysema, and observed significant air-trapping to be present in 6. Heart size was normal in all patients. On laminagraphic analysis, R.G.F. consistently assessed the vascular pattern as normal in all these patients (Fig. 2, 13, 15 and 16) except for one "doubtful" evaluation in Case 35. The assessment in Cases 34 and 37 was made during an episode of bronchospasm and at the same time as the first group of function tests shown.

The first patient in Table II (Case 27) illustrates the extensive ventilatory changes that may be caused by spasmodic asthma

in the absence of change in pulmonary diffusing capacity or in the pulmonary vascular pattern as observed laminagraphically. This twenty-five year old man had had severe asthma for ten years, and his chest appeared remarkably expanded and barrel-shaped. This was reflected by the finding of a functional residual capacity of 5.4 liters, and a mixing efficiency of only 24 per cent. The extreme ventilatory disability was illustrated by the maximal ventilatory volume which was 13 L/min. and the maximal midexpiratory flow rate of 0.2 L/sec. In spite of these findings the resting diffusing capacity by end tidal sampling was 26.0 cc. CO/min./mm./Hg. R.G.F. noted the presence of marked air-trapping on the plain roentgenograms (Fig. 1*B*), but the arterial pattern on the body section roentgenograms was consistently assessed as "normal" (Fig. 2*B* and 13). A similar "normal" assessment was recorded in Case 37 (Fig. 15 and 16), whose roentgenograms were taken at the same time that the first series of function tests were performed. In this patient, however, the extreme bronchospasm had presumably caused several focal areas of atelectasis in the lung, dem-

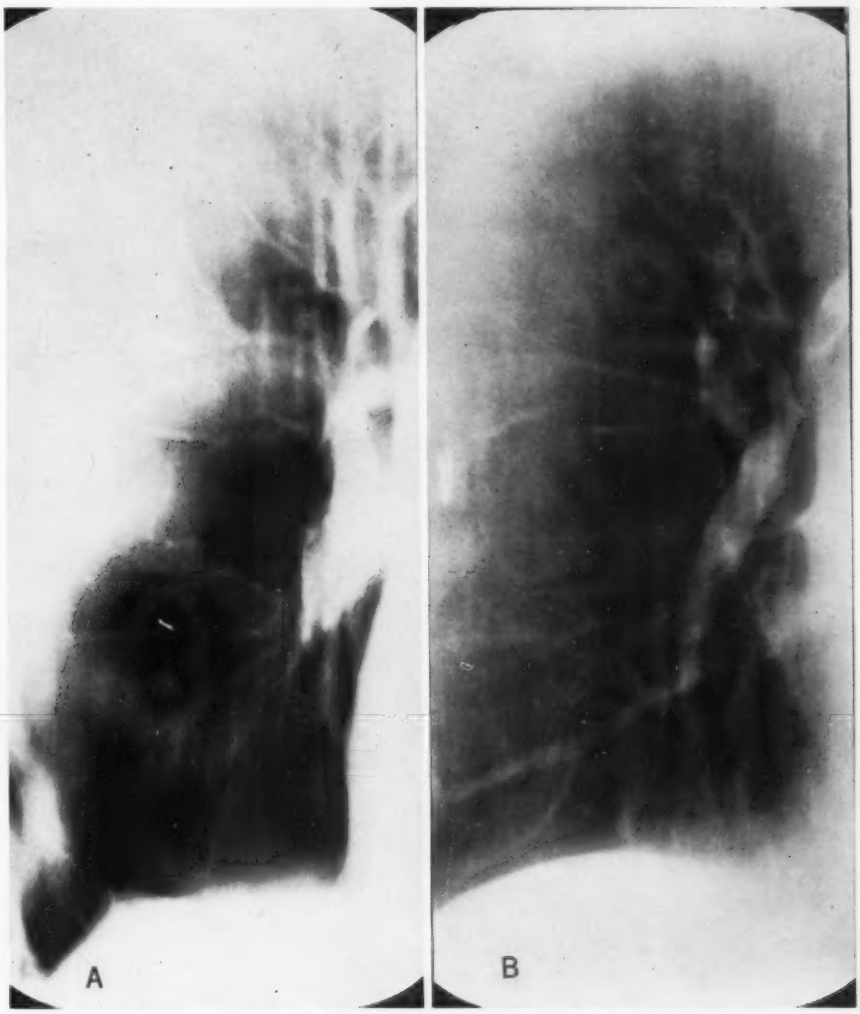


Fig. 6. Same case as in Figure 4 and 5. (*A*) LogEtronic reproduction of the right lung field of the body section roentgenogram demonstrated in Figure 5. (*B*) The marked deficiency in the peripheral vasculature is contrasted with the normal vasculature as demonstrated in the LogEgram of the right lung field in the normal control.

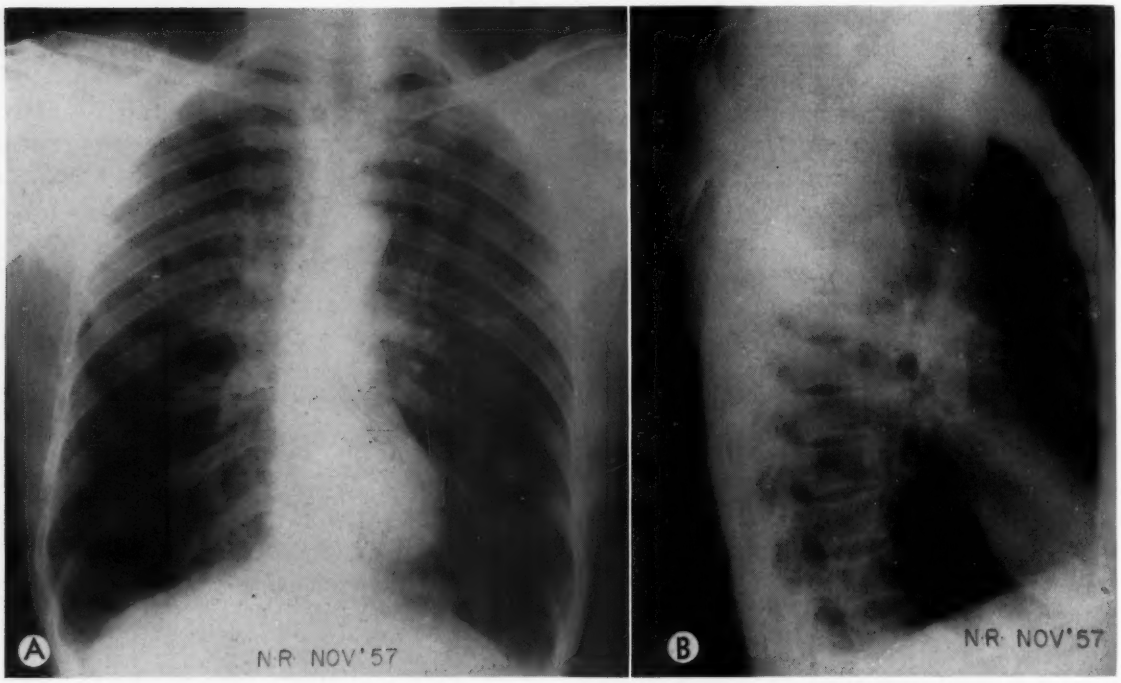
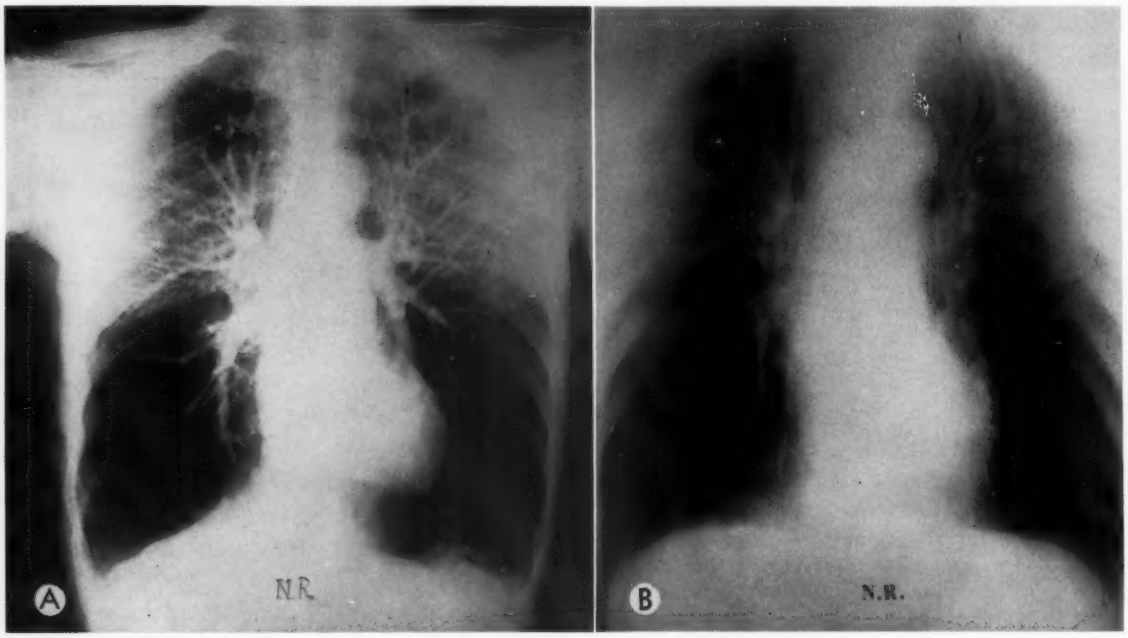


FIG. 7. Case 16, Table 1. (*A* and *B*) Pulmonary emphysema. Posteroanterior and lateral roentgenograms of a forty-eight year old man who had experienced steadily progressive dyspnea for five years, now incapacitating. Sputum was always minimal, and no distinct episodes of bronchitis were noted. The only abnormality on physical examination was reduced air-entry over both bases with minimal evidence of bronchospasm. There was no right heart failure. The films demonstrate evidence of moderate air-trapping. There is a suggestion of some deficiency of the arterial vasculature to the lower half of each lung, although the vessels to the upper portions of the lungs do not appear abnormal.



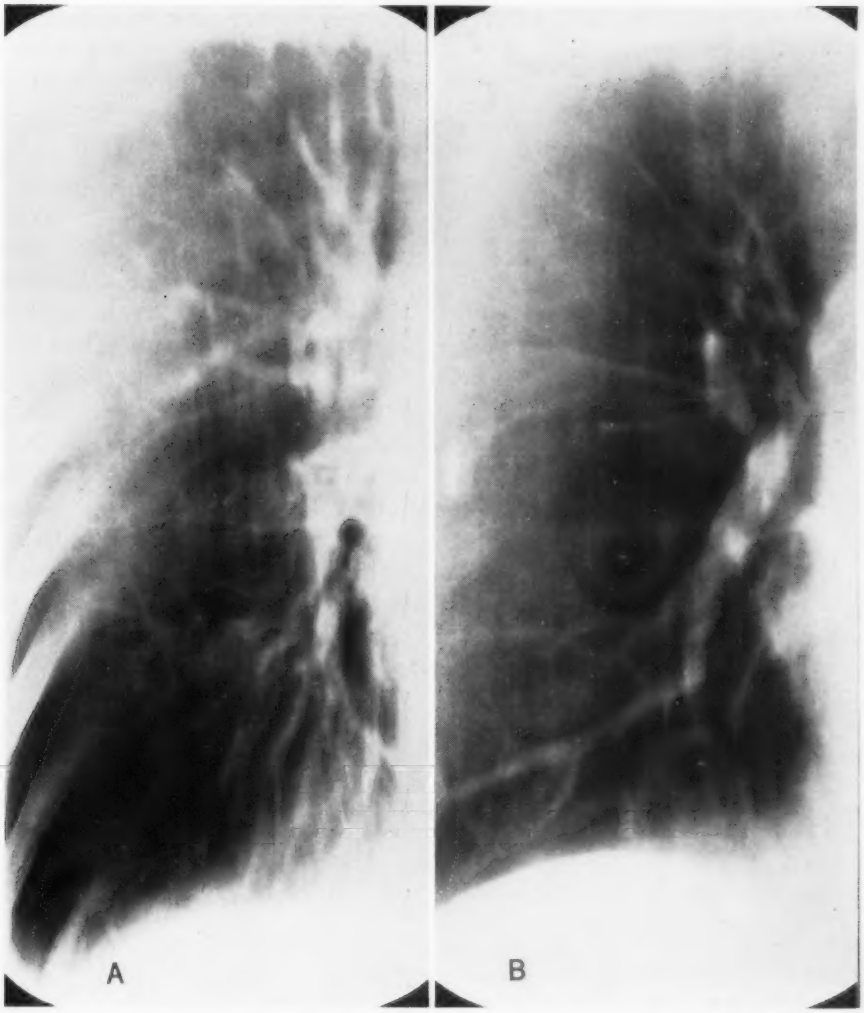


Fig. 9. Same case as in Figure 7 and 8. (*A*) LogEtronic print of the right lung field of the body section roentgenogram reproduced in Figure 8*B*, compared with the normal control (*B*).

onstrated roentgenologically in the right lower lobe (Fig. 14). It will be noted that the FRC increased on relief of the spasm, at which time the atelectasis was seen to have disappeared roentgenologically (Fig. 17). The low initial diffusing capacity presumably reflects the decrease in area of pulmonary vascular bed being ventilated during the period of intense bronchospasm.

3. SPECIAL CASES

In Table III are set out the results in 6 patients whose findings are of particular interest, since they either illustrate discrepancies between the clinical, physiologic and roentgenologic evaluation, or they raise problems in diagnosis not revealed by the study of straightforward cases of asthma and emphysema.

Fig. 8. Same case as in Figure 7. (*A*) Pneumoangiogram confirms the suspicion of deficiency of arterial vasculature in the lower half of each lung. The contrast between the size of the vessels in the lower half of each lung with those in the upper is striking. (*B*) Body section roentgenogram demonstrates vessel caliber and distribution to almost as good an advantage as the pneumoangiogram, bearing in mind that the laminagram visualizes vessels in a limited thickness of lung. Subsequent removal of the left lower lobe in this patient has confirmed the presence of advanced centrilobular emphysema within it.

FIG. 10. Case 12, Table 1. Pulmonary emphysema. The posteroanterior roentgenogram of a forty-nine year old woman who had a four year history of progressive dyspnea associated with minimal bronchitis. Recent marked weight loss was noted. Physical examination revealed only an occasional rhonchus and slight impairment of air-entry over the upper lung fields. The patient had no right heart failure but there was definite electrocardiographic evidence of right ventricular hypertrophy. The roentgenogram shows a moderate degree of air-trapping (the lateral projection is not reproduced) but the most striking change is a disparity between the size of the pulmonary arteries extending into the upper half of the two lungs and those into the lower half. Few vessels are visualized in the upper half of the two lungs.

The first patient (Case 38) was clinically a case of spasmodic asthma. The low maximal ventilatory volume was observed during an attack, and she had minimal dyspnea when free of bronchospasm. The diffusing capacity when not in spasm was 16.5 cc. CO/min./mm./Hg and the helium mixing efficiency 62 per cent. R.G.F. considered that the plain roentgenograms revealed evidence of severe air-trapping and, in addition, suggested the presence of emphysema. The body section roentgenograms were interpreted consistently as indicating emphysema. It is not possible, of course, to say who is right in this assessment, but clearly such a patient must be carefully observed to see whether the future reveals the answer to the diagnostic problem.

The second patient (Case 39), an obese man of fifty-five years of age with chronic bronchitis and bronchospasm, was found to have a normal FRC, an almost normal maximal ventilatory volume, but a reduced maximal midexpiratory flow rate. The diffusing capacity was normal. R.G.F. interpreted the plain roentgenograms as normal (Fig. 18), and made a consistent diagnosis of emphysema on the basis of the pulmonary vascular pattern seen laminagraphically (Fig. 19 and 20). The third patient (Case 40) had a long history of chronic bronchitis with some bronchospasm, but with very little dyspnea. He was able to walk without dyspnea at three miles an hour at a grade of 1 in 15 on the exercise treadmill, and on the basis of the MVV of 76 and the diffusing capacity of 22.6 was considered to have very little in the way of

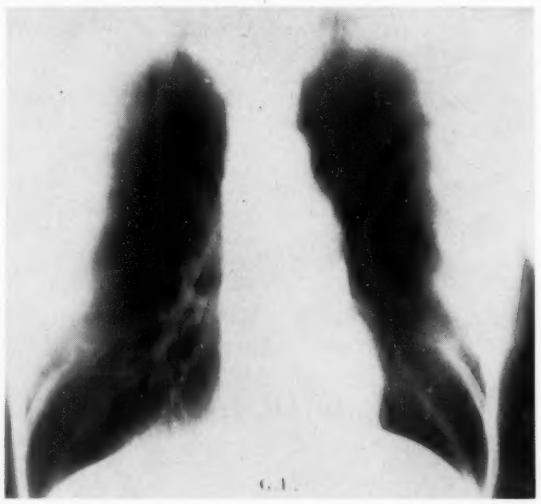


FIG. 11. Same case as in Figure 10. Body section roentgenogram demonstrates an almost complete absence of arteries in the upper portion of the two lungs. The vessels in the lower half of the two lungs are either normal or perhaps slightly increased in caliber. Subsequent autopsy on this patient has confirmed the presence of advanced pulmonary emphysema practically confined to the two upper lobes.

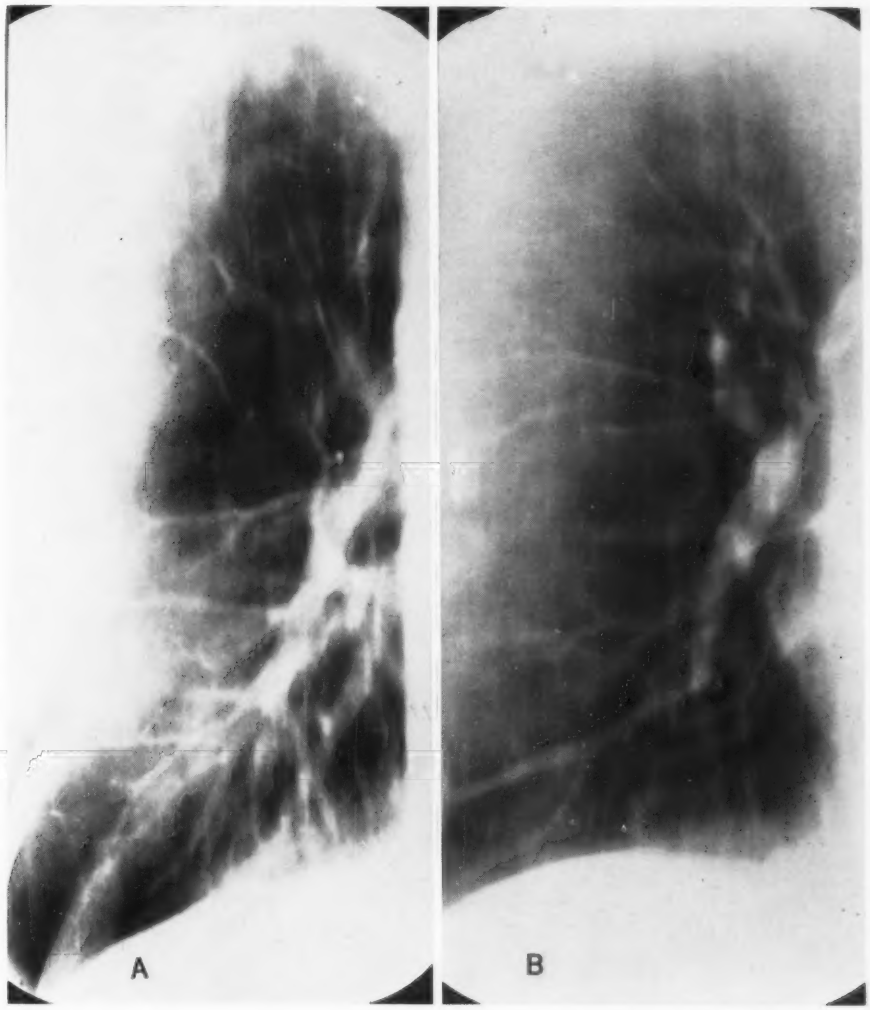


Fig. 12. Same case as in Figure 10 and 11. (*A*) LogEtronic reproduction of the right lung field of the body section roentgenogram seen in Figure 11, compared with the normal control (*B*).

emphysema. R.G.F. interpreted the plain roetngenograms as showing not only severe air-trapping but also suggestive evidence of emphysema as revealed by the peripheral vasculature. Evaluation of the body section roentgenograms was inconsistent, however, being interpreted on one occasion as normal, and on two other occasions as doubtful. Not much is known about the transition from chronic bronchitis to pulmonary emphysema, and it is clear that patients such as Case 39 and 40 will be found in which roentgenologic distinction is difficult.

Case 41 was that of a sixty-five year old man who complained of increasing dyspnea and was referred for pulmonary function studies on this account. The plain roentgenograms of the chest showed a diffuse fine reticulation throughout both lung fields without any characteristics that would allow a definite roentgenologic diagnosis to be made. The evaluation of the pulmonary vessels laminagraphically by R.G.F. was clearly much in favor of assessing these vessels as normal. The function tests showed very considerable impairment of diffusing capacity with fairly good ventilatory function. The pCO_2 was only 32 mm. of mercury and there was some polycythemia. The final diagnosis in this pa-

Fig. 13. Case 27, Table II. Spasmodic asthma. A twenty-five year old man with a long history of allergic asthma with minimal exercise dyspnea when not in an attack. Chest held in a position of maximal inspiration. Pulmonary function tests showed a large FRC and gross ventilatory impairment but a normal pulmonary diffusing capacity. (*A*) LogEtronic reproduction of the right lung field seen in the body section roentgenogram reproduced in Figure 2*B*, contrasted with a normal control (*B*). The plain roentgenogram of the chest on this patient is reproduced in Figure 1*B*.

tient was pulmonary infiltration of unknown type leading to a diffusion defect, and it was clear that emphysema was unlikely to be playing any part in his condition.

Case 42 represented a classic instance of the alveolar hypoventilation syndrome associated with gross obesity. With arterial unsaturation and CO_2 retention, she was found to have a good maximal ventilatory volume and a normal pulmonary diffusing capacity. Both on plain roentgenographic and laminagraphic assessment, R.G.F. consistently recorded the pulmonary vasculature as normal.

The last patient (Case 43) is included because he may represent a very early diagnosis of pulmonary emphysema. A hospital employee, he was selected as an "old normal" subject for studies on the pulmonary diffusing capacity on exercise. This was found to be more than two standard devia-

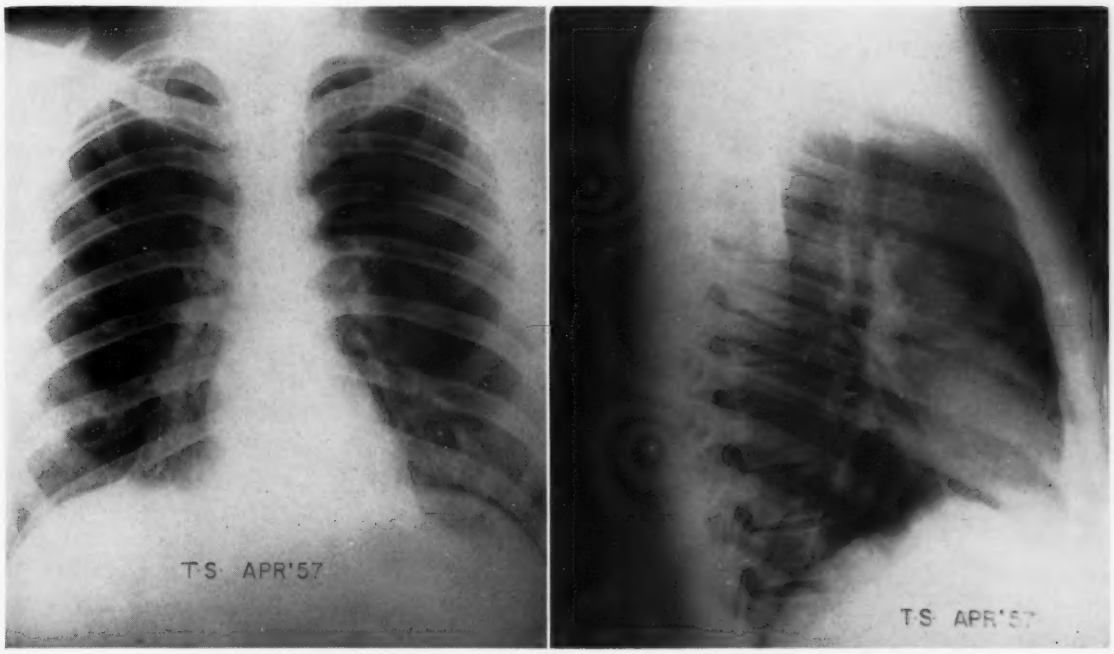


Fig. 14. Case 37, Table II. Spasmodic asthma. This twenty-four year old man had a long history of allergic rhinitis. There were no chest symptoms until eight months before the first examination in April, 1957 when his chief complaint was dyspnea. Only physical signs of moderate bronchospasm were noted. Posteroanterior and lateral roentgenograms of the chest do not demonstrate conspicuous air-trapping, in spite of gross ventilatory impairment. The triangular area of increased density in the right cardiophrenic angle was interpreted in the light of symptoms and signs as a predominantly atelectatic process. The lungs otherwise showed no abnormality.

tions below the predicted normal value for people in his age group, and, when the routine function tests were done, he was found to have an increase in the FRC, a reduced vital capacity, and a maximal ventilatory capacity of only 52 L/min. compared to a predicted value of 94 L/min. The maximal midexpiratory flow rate was only 0.9 L/sec. instead of 3.2 L/sec. He gave no history of bronchitis except for a very occasional morning blob of sputum in the winter. He was a very light smoker, and denied any dyspnea except that he was not as active as he had been twenty years before. Physical examination of the chest and electrocardiograms were normal. The routine preemployment chest roentgenograms had been reported as normal, and this was confirmed on re-evaluation, except for evidence of moderate air-trapping (Fig. 21). R.G.F. recorded the body section roentgenograms (Fig. 22 and 23) first as "normal" and then followed with two "doubtful" assessments.

Fig. 15. Same case as in Figure 14. Body section roentgenogram made during the acute episode in April, 1957 reveals a perfectly normal distribution and caliber of the arteries of both lungs, although the midportion of the left lung shows slightly greater relative translucency.

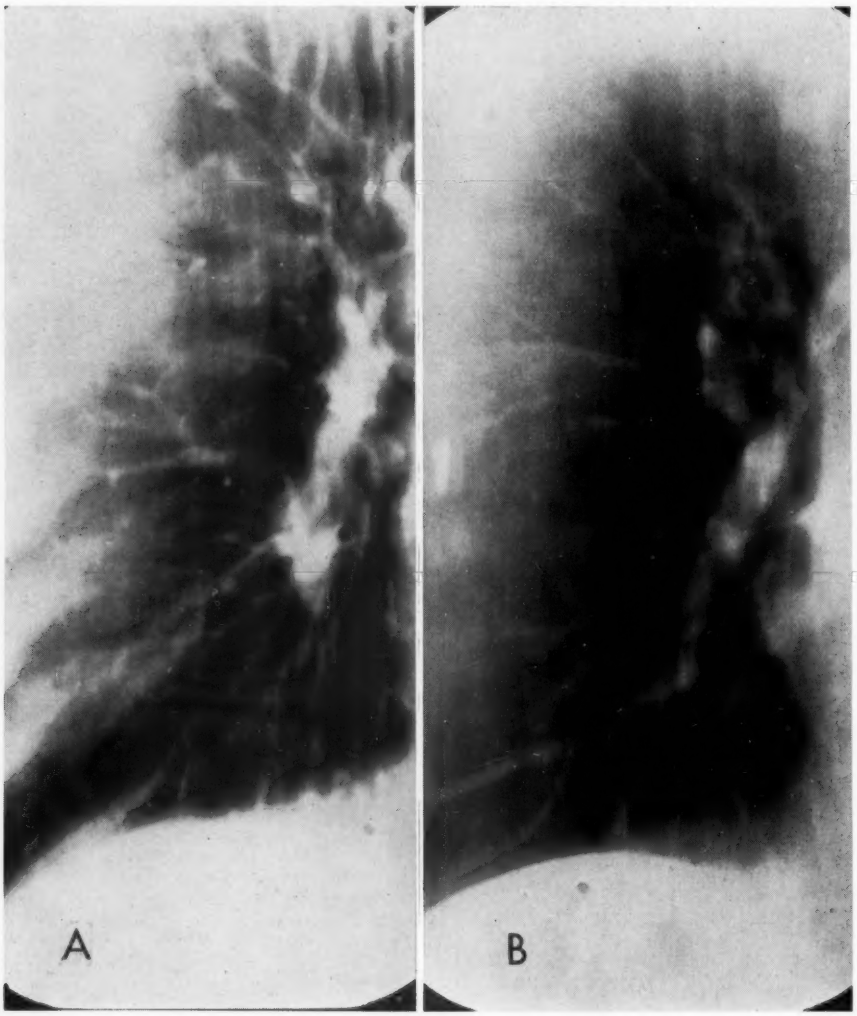


FIG. 16. Same case as in Figure 14 and 15. (*A*) LogEtronic reproduction of the right lung field seen in the body section roentgenogram reproduced in Figure 15, contrasted with the normal control (*B*).

There appeared to be some slight reduction in the vascularity to the left lower lobe, although as mentioned above, this region is difficult to assess because of being partly obscured by the heart density. This patient therefore represents the group of middle aged men who have minimal symptoms and no physical signs, yet show definite changes in pulmonary function in the direction of established pulmonary emphysema. It is to be presumed that patients of this type will show the early pathologic changes of centrilobular emphysema as described by McLean[24] and such cases illustrate the difficulty that is attendant upon the selection of a normal group of subjects of this sex and age.

DISCUSSION

In the evaluation of any diagnostic procedure, the technical simplicity or difficulty must be balanced against the value of the information obtained. The technique of body section roentgenography as discussed is neither difficult nor time consuming, and subjects the patient to minimal inconvenience. There is little doubt but that its more extensive use in problems of diagnostic difficulty in chronic lung disease would add considerably to our knowledge of these conditions.

It is obvious that the vascular abnormalities which are observed laminagraphically in emphysema would be even better appreciated by the technique of angiopneumography. De Clercq and his colleagues[13] have used this procedure in the study of the pulmonary arterial tree in emphysema, and their principal finding was that of a reduction in the peripheral vascular bed. This has been confirmed in 2 patients studied in this hospital by both body section roentgenography and angiopneumography (Case 16, Table 1, and a second patient with "unilateral emphysema" not included in this series) (Fig. 8). While appreciation of peripheral arterial deficiency was more striking in the angiopneumograms because of vessel opacification, the laminagrams were equally as convincing, not only as to degree of narrowing but as to distribution as well.

The results shown in the tables indicate that in the roentgenologic diagnosis of pulmonary emphysema, much more precision may be expected from body section roentgenography than from plain roentgenography. Indeed, the finding that even severe and advanced cases of emphysema cannot, on occasion, be diagnosed from plain roentgenograms of the chest would suggest rather strongly that body section roentgenography should be performed on all patients thought to have emphysema when there is any doubt about the diagnosis. Similarly, the use of laminagraphy in the evaluation of patients with a long history of spasmodic asthma might be expected to reveal whether or not there has developed any degree of lung destruction that might indicate the presence of early emphysema.

The recent stimulating work on the pathology of pulmonary emphysema by Heard[18] and that quoted above[17,24] leads naturally to the hope that the next few years may see a much clearer understanding of the roentgenologic and physiologic derangements of the disease interpreted in the light of the basic pathology. It is too early yet to say whether the diffuse gener-

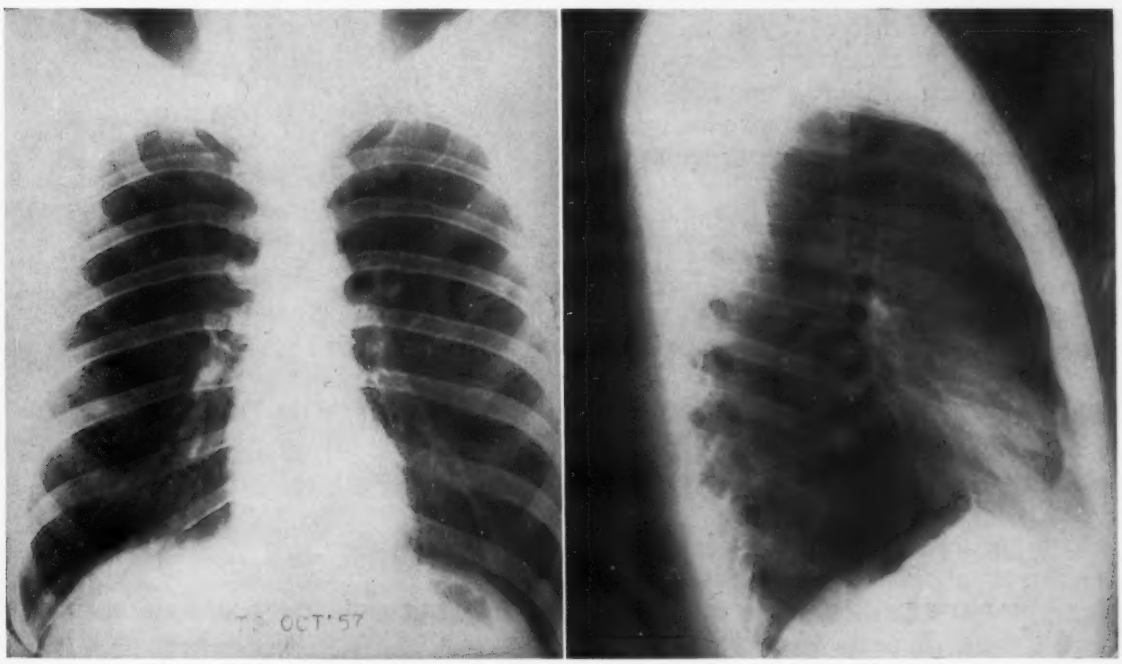


Fig. 17. Same case as in Figure 14, 15 and 16. Treatment with meticorten was begun in May, 1957 and continued through September of 1957 with complete relief of symptoms. Posteroanterior and lateral roentgenograms of the chest made in October, 1957 show disappearance of the focal area of atelectasis in the inferomedial portion of the right lung seen in Figure 14. The chest now appears normal.

Fig. 18. Case 39, Table III. This moderately obese fifty-five year old man had had bronchitis for the past few years but with scanty expectoration. Moderate dyspnea on effort was noted the past year. Physical examination showed diffuse bronchospasm. Posteroanterior roentgenogram of the chest does not suggest the presence of much air-trapping, nor does the peripheral vasculature of the lungs appear deficient.

alized type of emphysema described by the pathologists is reflected by a diffuse involvement of pulmonary vasculature that can be identified laminagraphically, or whether this type of generalized emphysema is distinguished by any particular pattern of respiratory function abnormality.

The frequency with which emphysema may occur in a localized form as stressed by Abbott and his group[1] is confirmed by the study of the body section roentgenograms here reported, and certainly suggests that the distribution of the destructive process is often not generalized, even at the stage when considerable respiratory disability exists (Case 16). The predominant finding of disappearance of vessels in either the upper or the lower lung fields suggests that future investigative work should perhaps be directed at attempts to localize the main parts of the lung affected more accurately than is possible at the moment. When this is realized physiologically, it might be feasible to relate it to the changes observable laminagraphically, though at the present this objective is beyond our reach.

Since our study was designed initially to explore the usefulness of body section roentgenography in the evaluation and differentiation of emphysema and asthma, it was considered sufficient to attempt to establish the validity of the method by an analysis of intra-observer variation only. Although a formal study of inter-observer variation was not specifically planned, an attempt was made to further assess the accuracy and simplicity of the method by submitting the laminagrams of 16 patients from the emphysema group to two panels of 13 doctors each, one a group of internists whose chief interests lay in diseases of the chest, and the other a group of radiologists of widely varying degrees of experience. The laminagrams on several normal patients were interspersed among the emphysema group for control purposes. While both

Fig. 19. Same case as in Figure 18. Body section roentgenogram reveals a rather rapid decrease in caliber of the peripheral arteries beyond the second and third stage divisions. The discrepancy between the size of the peripheral branches and the central hilar arteries is striking. This patient had slight ventilatory impairment but a perfectly normal diffusing capacity and was considered to be clinically suffering from chronic bronchitis without emphysema. See text for further discussion.

Fig. 20. Same case as in Figure 18 and 19. (*A*) LogEtronic reproduction of the right lung field of the body section roentgenogram reproduced in Figure 19, compared with the normal control (*B*).

panels recorded more diversity of opinion than R.G.F., in general there was majority agreement with him. In fact, one of the panels was unanimous in its assessment from laminagrams submitted to them of the presence of emphysema in 8 out of 16 patients. A more comprehensive assessment of inter-observer error is being planned for the near future, and is expected to be the subject of a separate communication.

SUMMARY AND CONCLUSIONS

1. Body section roentgenography has been performed on 26 patients considered to have hypertrophic pulmonary emphysema on clinical and physiologic grounds. The changes in pulmonary vasculature that have been described by others in this condition have been confirmed as being readily visible on laminagrams, and evidence is presented to suggest that this is a useful and simple technique of assessment.

2. Eleven patients with spasmodic asthma have been similarly studied and their pulmonary vasculature found to be consistently preserved.

3. In a few cases there is a discrepancy between the assessment based on clinical and physiologic criteria and that based on body section roentgenography. Such cases

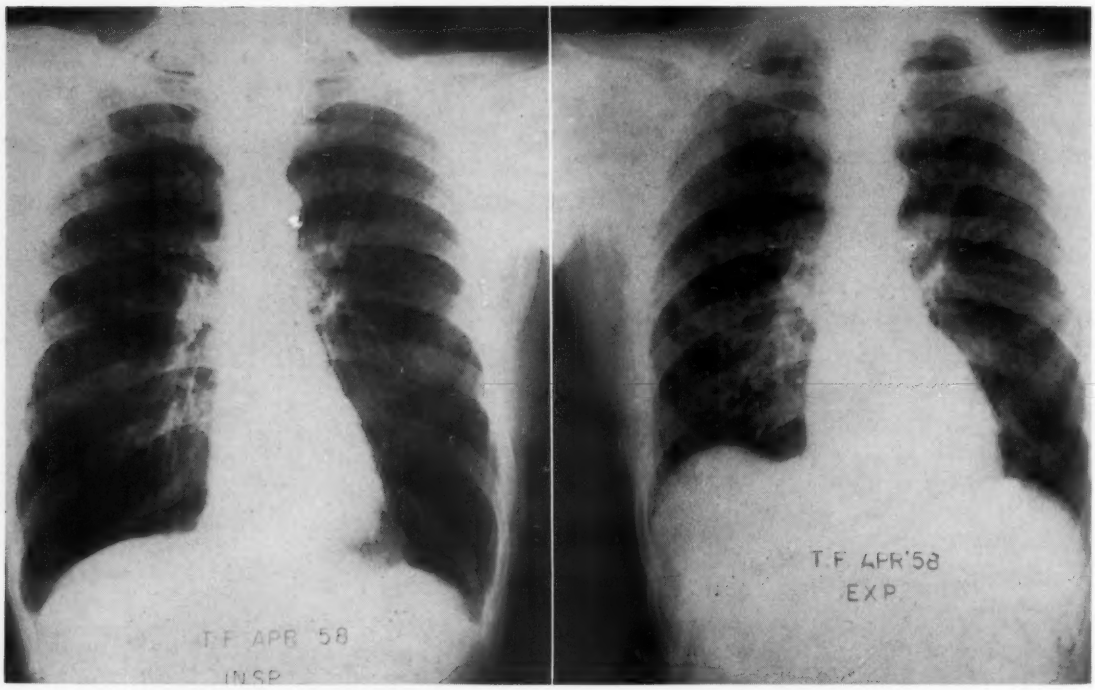
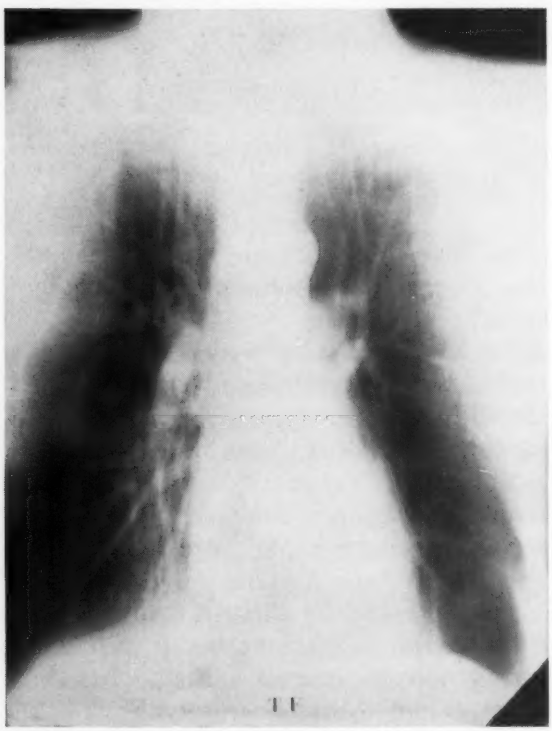


FIG. 21. Case 43, Table III. ?Early emphysema. This fifty-three year old hospital porter had had an occasional blob of sputum in the morning for several years but has noticed no dyspnea. He never lost a day of work because of chest symptoms. He was selected as "old normal" subject in a study of exercise diffusing capacity, which was found to be significantly lower than predicted. Other pulmonary function tests were altered in a direction supporting a diagnosis of pulmonary emphysema. Posteroanterior roentgenograms of the chest made in inspiration (*A*) and expiration (*B*) show good diaphragmatic excursion and no evidence suggesting air-trapping. The peripheral vasculature of the lungs does not appear abnormal.



must be the subject of further investigation and may illustrate important variations in the types of pulmonary emphysema being studied. The presence of a normal vascular tree is confirmed in a case of alveolar hypoventilation syndrome and in a patient thought to have a primary diffusion defect of the lung.

4. Body section roentgenography of the chest is recommended as a procedure of potential value in the investigation of unusual problems of chronic lung disease or

FIG. 22. Same case as in Figure 21. Body section roentgenogram demonstrates an essentially normal appearance of the peripheral vasculature of the two lungs, with the possible exception of some deficiency in the lower half of the left lung.

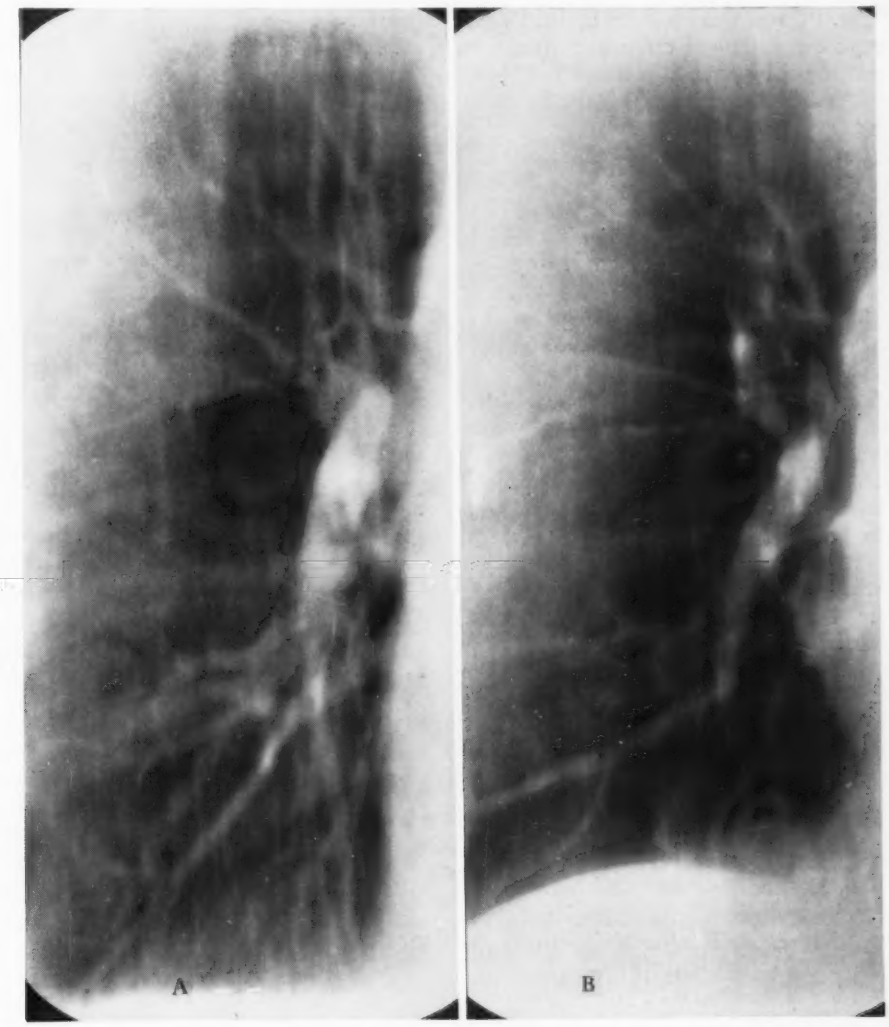


Fig. 23. Same case as in Figure 21 and 22. (*A*) LogEtronic reproduction of the right lung field of the body section roentgenogram reproduced in Figure 22, compared with the normal control (*B*).

of pulmonary hypertension and cor pulmonale.

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We wish to thank the physicians on the staff of the Royal Victoria Hospital who have referred to us their patients for study. In addition we would like to thank Dr. George Simon who suggested to one of the authors that a detailed study of the value of body section roentgenography in this condition might be rewarding. The assistance given us by Dr. Albert Jutras and Dr. Paul Roi, Hotel Dieu de Montréal, in the LogEtronic reproductions is much appreciated and is gratefully acknowledged.

REFERENCES

1. Abbott, O. A., Hopkins, W. A., Van Fleit, W. R., and Robinson, J. S. New approach to pulmonary emphysema. *Thorax*, 1953, *8*, 116–132.
2. Astrup, P. Simple electrometric technique for determination of carbon dioxide tension in blood and plasma, total content of carbon dioxide in plasma, and bicarbonate content in separated plasma at fixed carbon dioxide tension (40 mm. Hg). *Scandinav. J. Clin. & Lab. Invest.*, 1956, *8*, 33–43.
3. Barden, R. P. Interpretation of some radiologic signs of abnormal pulmonary function. *Radiology*, 1952, *59*, 481–486.

4. BARDEN, R. P., and COMROE, J. H., JR. Roentgenologic evaluation of pulmonary function: Correlation with physiologic studies of ventilation. AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED., 1956, *75*, 668–681.
5. BATES, D. V. Measurement of pulmonary diffusing capacity in presence of lung disease. *J. Clin. Invest.*, 1958, *37*, 591–603.
6. BATES, D. V. Uptake of carbon monoxide in health and in emphysema. *Clin. Sc.*, 1952, *11*, 21–32.
7. BATES, D. V., BOUCOT, N. G., and DORMER, A. E. Pulmonary diffusing capacity in normal subjects. *J. Physiol.*, 1955, *129*, 237–252.
8. BATES, D. V., and CHRISTIE, R. V. Intrapulmonary mixing of helium in health and in emphysema. *Clin. Sc.*, 1950, *9*, 17–29.
9. BATES, D. V., KNOTT, J. M. S. and CHRISTIE, R. V. Respiratory function in emphysema in relation to prognosis. *Quart. J. Med.*, 1956, *25*, 137–157.
10. BECKLAKE, M. R. New index of intrapulmonary mixture of inspired air. *Thorax*, 1952, *7*, 111–116.
11. BIRATH, G., and SWENSON, E. W. Correction factor for helium absorption in lung volume determinations. *Scandinav. J. Clin. & Lab. Invest.*, 1956, *8*, 155–158.
12. CAMPBELL, E. J. M., MARTIN, H. B., and RILEY, R. L. Mechanisms of airway obstruction. *Bull. Johns Hopkins Hosp.*, 1957, *101*, 329–343.
13. DE CLERCQ, F., DE COSTER, A., DE BOLLAERT, A., DENOLIN, H., and ENGLERT, M. Aspects angiopneumographiques de l'emphysème pulmonaire diffuse. *Acta tuberc. belg.*, 1956, *47*, 194–208.
14. FILLEY, G. F., MACINTOSH, D. J., and WRIGHT, G. W. Carbon monoxide uptake and pulmonary diffusing capacity in normal subjects at rest and during exercise. *J. Clin. Invest.*, 1954, *33*, 530–539.
15. GILSON, J. C., and HUGH-JONES, P. Lung function in coal workers' pneumoconiosis. Special report series number 290, Medical Research Council; Her Majesty's Stationery Office, London, 1955.
16. GOLDEN, R. Abnormally wide respiratory movement of lower lung structures; roentgen evidence of obstructive emphysema. AM. J. ROENTGENOL. & RAD. THERAPY, 1940, *44*, 325–332.
17. GOUGH, J. Correlation of radiological and pathological changes in some diseases of lung. *Lancet*, 1955, *1*, 161–162.
18. HEARD, B. E. Pathological study of emphysema of lungs with chronic bronchitis. *Thorax*, 1958, *13*, 136–149.
19. HORNYKIEWYTSCH, T., and STENDER, H. S. Normale und pathologisch veränderte Lungengefässe im Schichtbild. *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, 1953, *79*, 44–51; 1953, *79*, 639–650; 1953, *79*, 704–713; 1954, *80*, 458–467; 1954, *81*, 36–45; 1954, *81*, 134–143; 1954, *81*, 455–467; 1954, *81*, 642–655; 1955, *82*, 228–236; 1955, *82*, 331–337; and 1955, *82*, 642–655.
20. KANE, I. J. Sectional Radiography of the Chest. Springer Publishing Co., Inc., New York, 1953.
21. KNOTT, J. M. S., and CHRISTIE, R. V. Radiological diagnosis of emphysema. *Lancet*, 1951, *1*, 881–883.
22. LEUALLEN, E. C., and FOWLER, W. S. Maximal midexpiratory flow. *Am. Rev. Tuberc.*, 1955, *72*, 783–800.
23. MARSHALL, R. Comparison of methods of measuring the diffusing capacity of lungs for carbon monoxide; investigation by fractional analysis of alveolar air. *J. Clin. Invest.*, 1958, *37*, 394–408.
24. MCLEAN, K. H. Histology of generalized pulmonary emphysema. *Australas. Ann. M.*, 1957, *6*, 203–217.
25. NAHAS, G. G. Spectrophotometric determination of hemoglobin and oxyhemoglobin in whole hemolyzed blood. *Science*, 1951, *113*, 723–725.
26. RIGLER, L. Discussion of paper by BARDEN, R. P. Interpretation of some radiologic signs of abnormal pulmonary function. *Radiology*, 1952, *59*, 488.
27. SCHOENMACKERS, J., and VIETEN, H. Das Verhalten der Lungengefässe bei verändertem Luftgehalt der Lunge (Untersuchungen am postmortalen Gefässbild). *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, 1952, *76*, 24–44.
28. SIMON, G. Principles of Chest X-ray Diagnosis. Butterworth & Co. Limited, London, 1956.
29. STENDER, H. S. Die Röntgensymptomatologie der Arteriitis pulmonalis und ihrer Folgezustände. *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, 1952, *76*, 316–323.
30. WESTERMARK, N. Importance of intra-alveolar pressure in diagnosis of pulmonary diseases. *Radiology*, 1948, *50*, 610–617.
31. WHITFIELD, A. G. W., SMITH, O. E., RICHARD, D. G. B., WATERHOUSE, J. A. H., and ARNOTT, W. M. Correlation between radiological appearances and clinical and spirometric state in emphysema. *Quart. J. Med.*, 1951, *20*, 247–260.
32. WILLIAMS, M. H. Communication to Aspen Conference on Emphysema, 1958.

Vol. 82, No. 1

IDIOPATHIC UNILATERAL HYPERLUCENT LUNG: A ROENTGENOLOGIC SYNDROME*

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DURING the past few years we have seen several cases showing abnormal radiolucency of one lung, which could not be classified among the usual entities known to cause this appearance. In these patients the involved lung retained its radiolucency on expiration and there was an associated mediastinal shift identical to that seen in obstructive emphysema. Yet the main bronchus supplying the affected portion of the lung was normal in caliber. On bronchography a rather distinctive bronchiectatic pattern was seen, confined to the radiolucent lobe or lung. The intrapulmonary vasculature appeared diminished on the affected side, although the main pulmonary artery was present.

This combination of the roentgen signs of unilateral emphysema, a normal main bronchus but abnormal small bronchi, and a diminished vascular pattern results in a readily recognizable complex which appears to represent a genuine roentgenologic entity. We have selected the name "idiopathic unilateral hyperlucent lung" for this syndrome. Not enough is known of its pathogenesis to justify a more specific title. The present report is based on a study of 4 cases of this condition.

REVIEW OF LITERATURE

Several reports in the literature appear to be concerned with this entity. In 1953, Swyer and James[19] reported a case of a six year old boy who had had repeated episodes of bronchitis and bronchopneumonia. A chest roentgenogram showed increased transradiancy of the right lung with marked decrease in its vascular markings. The right hemithorax and lung were smaller than the left and the heart was displaced slightly to the right. On fluoroscopy, the heart shifted toward the right on inspiration and there was some restriction of respiratory excursion of the right hemidiaphragm. Bronchography showed abrupt termination of the larger bronchi on the right, but normal left-sided filling. Bronchoscopy was normal. Angiocardiography revealed a normal-sized heart, decreased caliber of the right pulmonary artery, and a paucity of vessels in the right lung with increased circulation in the left. A right pneumonectomy was performed. The right pulmonary artery was of larger caliber than that suggested by the angiogram. Dissection of the bronchial tree of the resected lung showed normal branching. Microscopically, there were many cystic spaces of varying diameter in the lung, some of which resembled dilated respiratory bronchioles. There was widespread obliteration of the peripheral lung capillaries in the walls of emphysematous alveoli. The authors considered the diminution in pulmonary vasculature to be secondary to the lung disease and believed that the cystic changes in the lung were more likely acquired than congenital.

Macleod,[12] in 1954, reported 9 adult cases with abnormal transradiancy of one lung, several of which appear similar to our patients. In each of Macleod's cases the affected lung showed increased translucency, more marked on expiration, with decreased vascular markings and a small hilar shadow. On inspiration the mediastinum was normal in position in 3 cases and displaced toward the hyperlucent side in 6. In each case the mediastinum shifted toward the normal lung on expiration. The diaphragmatic excursion was diminished on the af-

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fected side. On bronchography no block was demonstrated in the major bronchi, and all the segmental bronchi were filled. In some cases the bronchial lumens were slightly irregular in caliber and in 3 cases there were locules of oil attached like buds to the bronchi. Scanty or absent alveolar filling was noted. Pathologic material was not available for study.

In 1957, Dornhorst, Heaf, and Semple[4] reported 4 similar cases. In 2 of their cases pulmonary function studies indicated severe nonvalvular obstruction of the smaller bronchi on the affected side. They also traced 5 of the 9 patients reported by Macleod. Chest roentgenograms, available in 3, were unaltered, and the clinical status of all 5 had not changed in the three year interval.

Several articles dealing with hypoplasia or abnormal development of a pulmonary artery have included cases which resemble ours. In 1957, Belcher and Pattinson[2] recorded 3 cases in which a lobe showed increased radiolucency but occupied less space than normal. In one, the right lower lobe appeared emphysematous, yet smaller than normal, and the heart was deviated slightly to the right. A bronchogram was described as revealing "budding" along the bronchi of this lobe. Angiocardiography showed decreased arterial circulation in the right middle and lower lobes. At operation the right lower lobe appeared emphysematous, although smaller than normal, and its lobar pulmonary artery measured only 5 mm. in diameter. Elder *et al.*[5] reported 5 cases of hypoplasia or absence of a pulmonary artery. Two were described as showing bronchiectasis on the side of a hypoplastic pulmonary artery. The bronchograms were not reproduced. Laur and Wedler[11] reported 20 cases of "unilateral bright lung," in 17 of which the cause of the abnormality was thought to be asymmetry of development of the pulmonary vessels. Heier[8] described 3 cases of unilateral abnormal radiolucency of a lung, attributing the findings to unilateral pulmonary artery hypoplasia. Bronchographic findings were not mentioned in either of the latter two papers. Vaughan[21] discussed various syndromes associated with a small pulmonary artery.

REPORT OF CASES

CASE 1. C. T., a twenty-five year old white male, was admitted to the Jewish Hospital early in 1958 for investigation of low back pain. A routine photofluorogram of the chest showed a striking difference in the radiolucency of the two lungs. Past history revealed that he had inhaled a piece of cork at the age of six months, and had subsequently developed severe pneumonia which required prolonged hospitalization. During his childhood and adolescence he experienced occasional episodes of severe acute bronchitis or pneumonia. He had another episode of pneumonia of the right lung in 1952. Since that time he has noted a mild chronic cough, productive of small amounts of mucopurulent sputum, and some shortness of breath. Recently, an episode of hemoptysis occurred during heavy exertion. His exercise tolerance decreased somewhat during the past few years. Family history revealed that a maternal aunt had died of pneumonia at the age of twenty-five, that one brother had died at the age of two apparently of pneumonia, and that two of his own four children had had recurrent bronchial infections.

Physical examination revealed a thin white male with diminished expansion of the left hemithorax. Breath sounds were distinctly decreased over the entire left chest. Wheezes were heard throughout both lung fields and râles were noted in the lower portion of the left chest.

Inspiratory and expiratory roentgenograms (Fig. 1) and fluoroscopy of the chest showed the left lung to be more radiolucent than the right. The excursion of the left leaf of the diaphragm was extremely limited, and the left lung remained radiolucent on expiration. On inspiration the heart shifted toward the left hemithorax, and on expiration it moved back to a normal position. Several emphysematous bullae were visible in the left lung. Bronchograms (Fig. 2) showed that the left main stem, lobar, and segmental bronchi were all widely patent and of normal distribution. There was irregular fusiform dilatation of many of the small bronchi. The terminations of some of the smaller branches formed small clubs or buds. There was almost no alveolar filling. The right bron-

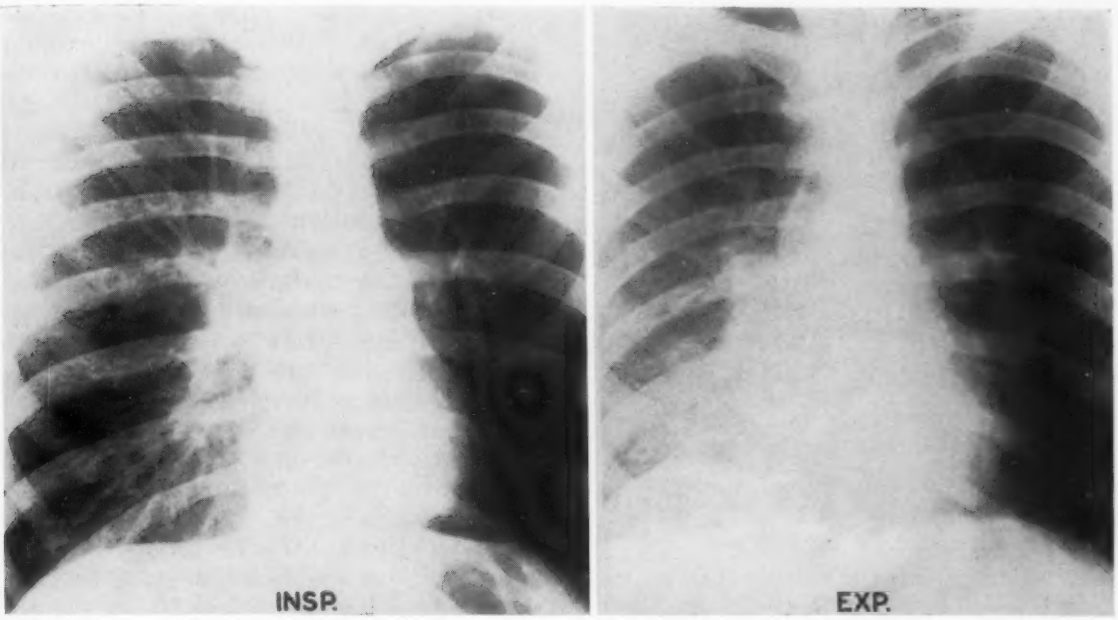

Fig. 1. Case 1. Inspiration and expiration roentgenograms. There is hyperlucency of the left lung, which persists on expiration. Note the shift of the mediastinum, poor excursion of the left hemidiaphragm and rib cage, and a relatively small left hilar shadow.

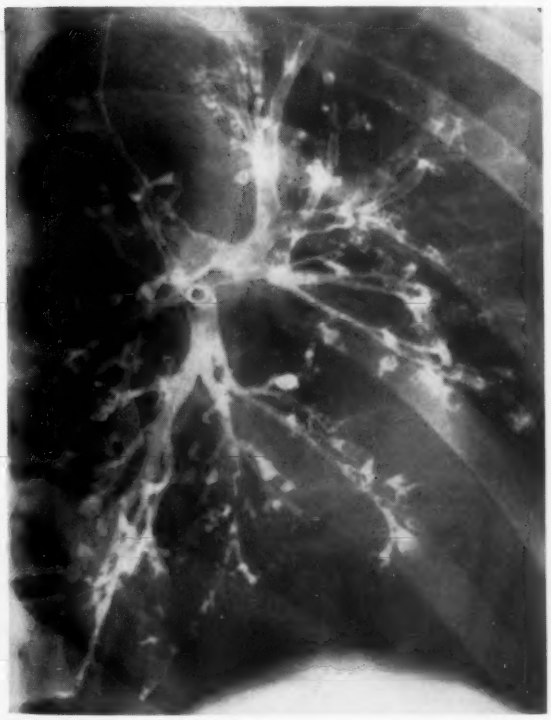

Fig. 2. Case 1. Left bronchogram, oblique projection. There is a normal distribution of segments, patency of the main bronchi, and irregular fusiform dilatation of many of the branches, with bud-like projections and terminal club formation. There is no alveolar filling.

chial tree was not completely filled but showed a normal appearance. Laminagrams and angiocardiograms (Fig. 3) demonstrated that the main pulmonary artery and its right and left branches were present. However, the left main pulmonary artery was small and its branches were considerably decreased in caliber and number. The right lung showed increased vascularity, presumably a compensatory phenomenon.

Pulmonary function studies showed an obstructive deficiency of moderate degree (one-second timed vital capacity—64 per cent; maximum breathing capacity—76 per cent). Differential bronchospirometry was attempted on two occasions but was not successful. Arterial oxygen studies revealed no desaturation (93 per cent after exercise).

The patient's back pain improved on treatment and he was discharged from the hospital. One month later he was admitted to the Cincinnati Veterans Hospital with a diagnosis of bronchopneumonia of the left lower lobe. Bronchoscopy, performed on this admission, was entirely normal.

Case II. (Courtesy of Drs. Slutzker, Shaw, and Tomashevski of the Dayton Veterans Hospital. This patient is also being reported in a paper to be published by this group.[17]) D.P., a

FIG. 3. Case I. Pulmonary angiogram. Note the small left main pulmonary artery and the sparseness of the branches throughout the left lung. There is compensatory increase in circulation on the right.

twenty-eight year old white male machinist, was admitted to the Dayton Veterans Hospital on July 26, 1957, complaining of shortness of breath and chest soreness of one year's duration. For nine years he had had a cough productive of minimal amounts of whitish sputum. The sputum recently had become brown in color. Four months prior to admission he had an episode of left chest pain. On three recent occasions he coughed up small blood clots. Past history indicated that, as a child, he had aspirated a carpet tack but had immediately coughed it up. He had also suffered from an attack of pertussis during childhood. In 1951, he had a bout of pneumonia.

On physical examination the patient seemed well. Respiratory excursions were equal bilaterally, and the percussion note over both lungs was slightly but equally hyperresonant. Breath sounds were decreased over the right lower lobe and scattered expiratory wheezes were heard in this region. Numerous small crepitant râles which cleared on cough were heard posteriorly over the right midlung field.

Inspiratory and expiratory roentgenograms (Fig. 4) and fluoroscopy of the chest revealed hyperlucency of the right lower lung field and restricted motion of the right leaf of the diaphragm. There was shift of the mediastinal structures toward the left hemithorax on expiration and back to a normal position on inspiration. On expiration the entire left lung and the right upper lung field became normally clouded, but the lower half of the right lung remained radiolucent. Bronchoscopy was normal. Bronchographic examination (Fig. 5) showed irregular fusiform dilatation of most of the branches

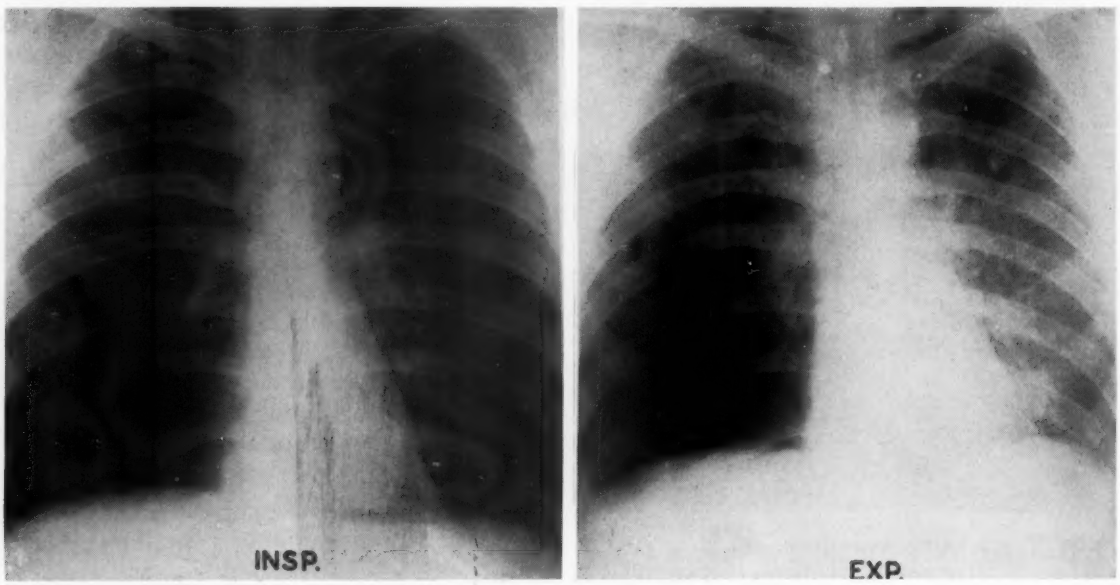

FIG. 4. Case II. Inspiration and expiration roentgenograms. There is radiolucency of the right lower lung field, persisting on expiration, with associated mediastinal shift and restricted movement of the right hemidiaphragm. The right hilus is relatively small.

of the right middle and lower lobes. Cystic dilatation of the terminal portions of many of the smaller bronchi was apparent, and there was a striking lack of alveolar filling. The bronchi of the right upper lobe and of the left lung appeared normal.

Laboratory studies demonstrated normal arterial oxygen saturation (96.8 per cent after exercise). Pulmonary function data showed a marked decrease in vital capacity (58.8 per cent) but the three-second timed vital capacity (92.3 per cent) apparently indicated that this was not due to an obstructive abnormality. The maximum breathing capacity (58 per cent) was reduced to the same degree as the vital capacity. Differential bronchospirometry showed, on the right side, normal ventilation but low oxygen uptake (24 per cent of the total).

A thoracotomy was performed. Pleural adhesions were noted over the entire right hemithorax, more marked inferiorly. The right lower lobe felt crepitant and contained no bullae or cysts. The right main pulmonary artery and its lobar branches appeared normal. No anomalous vessels were seen. A right lower lobectomy was performed. Grossly, the lobe appeared normal externally and on cut surfaces.

Microscopic sections (Fig. 6) from various sites of the specimen showed that the chief abnormality was in the bronchi. The bronchial walls appeared distorted and thickened by both

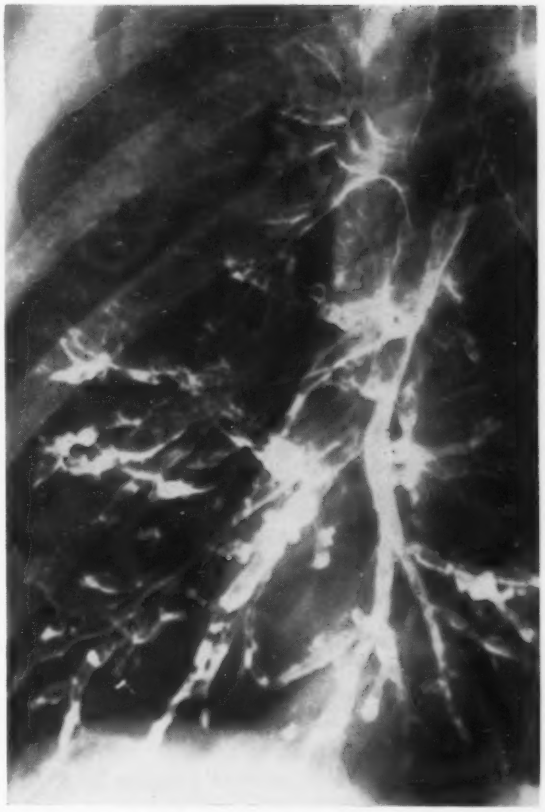

Fig. 5. Case 11. Right bronchogram, oblique projection. There is normal distribution of segments, with irregular fusiform dilatation, and lack of alveolar filling in the right middle and lower lobes.

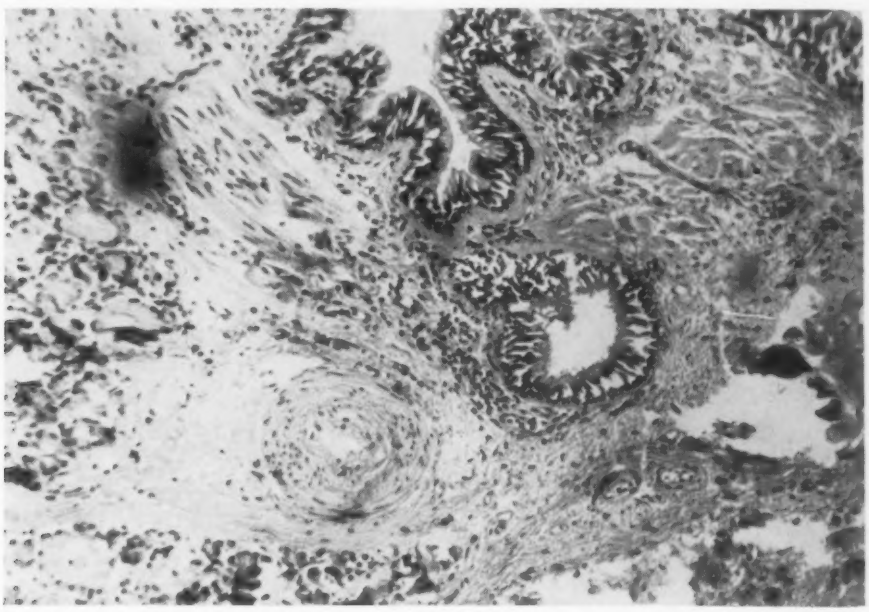

Fig. 6. Case 11. Microscopic section of resected right lower lobe. There is hyalinization of basement membranes, round cell infiltration, and smooth muscle hyperplasia. The findings are nonspecific.

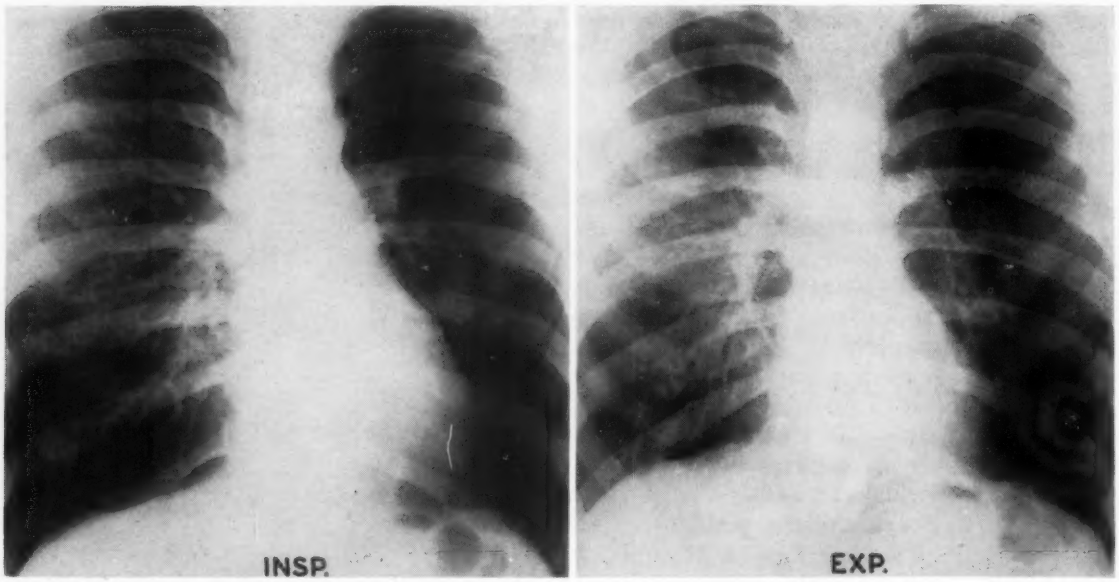

FIG. 7. Case III. Inspiration and expiration roentgenograms. Note the swing of the mediastinum, retention of radiolucency on the left on expiration, and diminished motion of the left hemidiaphragm. Emphysematous bullae are present in the lower left lung.

scar tissue and excessive smooth muscle, and showed occasional areas of ossification. The bronchi immediately beneath the pleura were rather large in caliber. Hyalinization of the basement membranes of the bronchioles was noted. Alveolar ducts and respiratory bronchioles were not recognized with the usual frequency, and microscopic areas of emphysema were present. There was hypertrophy of smooth muscle of the bronchial arteries. The slides were submitted to several pathologists, but a specific pathologic diagnosis could not be made. Some felt that there was chronic bronchitis, and one thought that bronchiectasis was also present. One considered the lesion to be congenital in nature.

Following operation, the patient was much improved. Postoperative differential bronchospirometry showed that the percentage of oxygen consumption by the right lung had increased only slightly (to 27 per cent). This indicated that the remaining lung tissue on the right side was now functioning slightly more efficiently than did the entire right lung before the lobectomy. The patient was last seen in July, 1958, at which time he was essentially asymptomatic.

CASE III. A.G., an immigrant boy, was first seen in the pediatric clinic at the Jewish Hospital in 1951, at the age of twelve, for a routine physical examination. He had had pneumonia at the age of three years and measles and pertussis during childhood. A chronic cough had been present since the bout of pneumonia. The cough was more severe in the winter and productive of white or greenish sputum. Physical examination revealed a marked increase in the anteroposterior diameter of the chest, widespread hyperresonance and generalized wheezes. There were râles and diminished breath sounds confined to the left lung.

Inspiratory and expiratory roentgenograms of the chest (Fig. 7) revealed hyperlucency of the entire left lung. The left hilus was smaller than the right. The radiolucency was most striking over the lower portion of the left lung where a number of emphysematous bullae were evident. There was restriction of motion of the left hemidiaphragm. On expiration the right lung clouded normally but the left remained hyperlucent. The mediastinal structures shifted toward the left side on deep inspiration and moved back to the midline on expiration. Bronchograms (Fig. 8) demonstrated mild irregular dilatation of the left bronchial tree. There was beading of many of the bronchi on this side, with bud-like protrusions projecting from many of the smaller branches, and terminal clubbing. There was almost complete absence of alveolar

filling. The right bronchial tree appeared normal. The paranasal sinuses showed evidence of bilateral chronic maxillary sinusitis.

He was treated for several months with postural drainage and antibiotics but his cough persisted and he failed to gain weight. Operation was recommended but refused. In March, 1953, he was re-admitted for evaluation for operation. Bronchoscopy at this time revealed no abnormalities. Bronchography was repeated and showed no progression. Operation was again advised and refused. In October, 1953, he developed a spontaneous left pneumothorax. The lung re-expanded under conservative therapy in about three weeks. He has been followed periodically since that time. The cough has improved and he has gained weight and developed normally. He has become an expert swimmer and diver. Chest roentgenograms and fluoroscopy in 1958 showed no change from the earlier studies. Pulmonary function studies have not been performed.

Case IV. J.C., a forty year old white male, was admitted to the Cincinnati General Hospital in 1952 because of the presence of a gross tremor of the head and both arms, which was subsequently attributed to conversion hysteria. During World War II he was discharged from service because of severe bronchial asthma and recurrent bronchopneumonia. He was troubled by a chronic cough, productive of about one pint of thick white sputum per day. Six months prior to admission he had had an episode of hemoptysis. He suffered from orthopnea and dyspnea on mild exertion. On physical examination a marked increase in the anteroposterior diameter of the chest was noted. Wheezes were heard over the entire thorax. There were râles and diminished breath sounds at the left base.

A chest roentgenogram showed distinct hyperlucency of the left lung. Inspiration and expiration roentgenograms (Fig. 9) and fluoroscopy demonstrated the heart to shift slightly toward the left on deep inspiration and to move back to a normal position on expiration. There was limitation of motion of the left leaf of the diaphragm. The left main pulmonary artery was smaller than the right and its intrapulmonary branches were sparse. Laminagraphy of the left lung confirmed this finding. Bronchography (Fig. 10) revealed irregular dilatation of the segmental bronchi of the entire left lung with small bud-like collections of contrast material arising from many of the smaller branches. There was minimal spill of contrast material into the alveoli. There was no evidence of constriction or obstruction of a major bronchus. The right

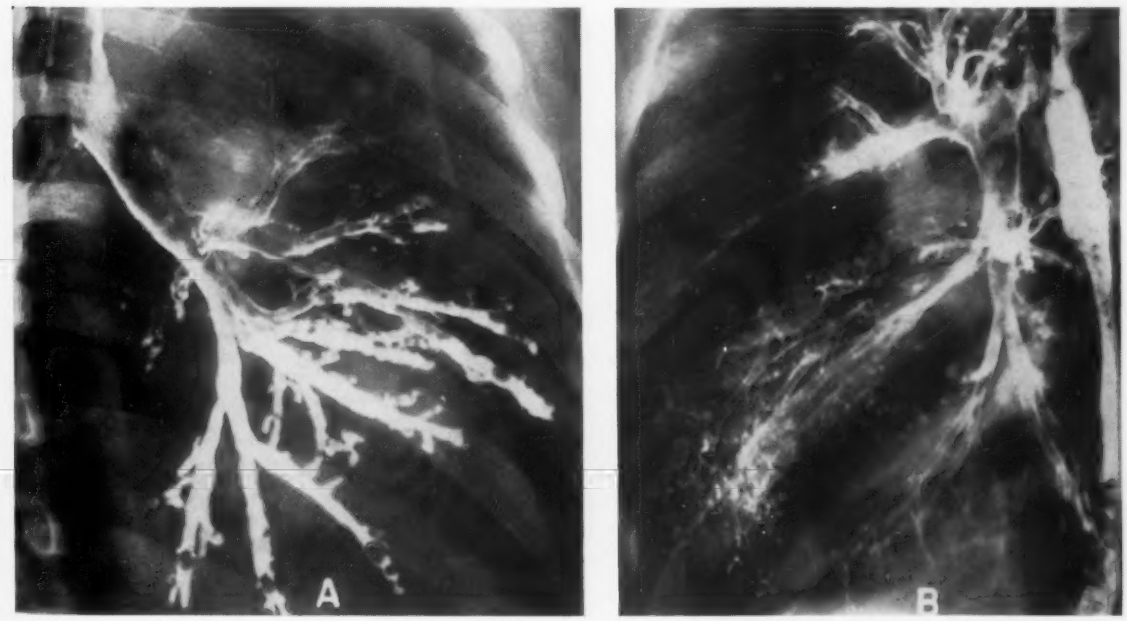

Fig. 8. Case III. Bronchograms of both sides, left (*A*) and right (*B*), oblique projections. Note the irregular dilatation and beaded appearance of the bronchi throughout the left lung, and the absence of alveolar filling. Distribution of segments is normal. The right bronchogram is normal.

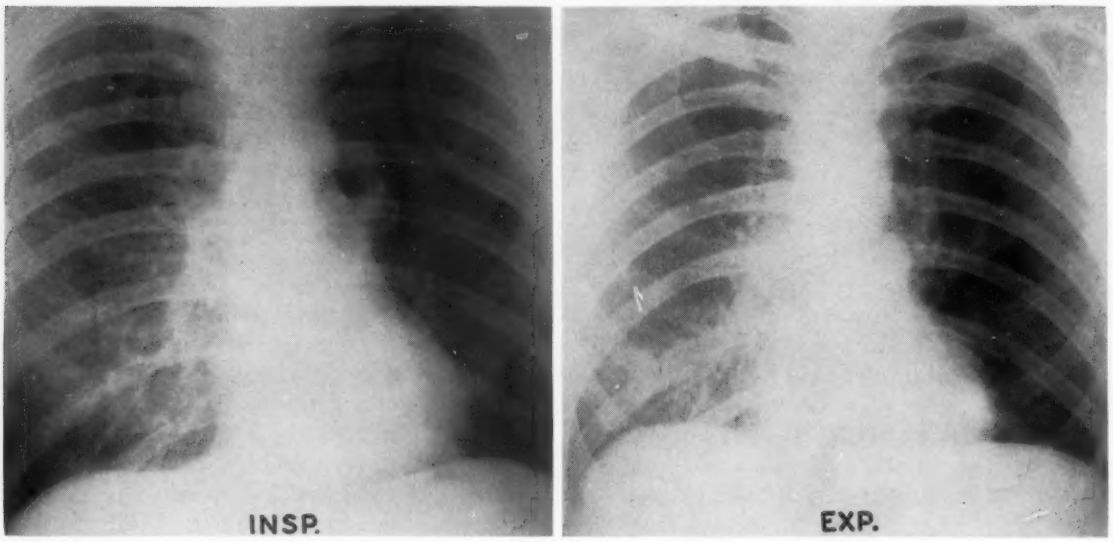

FIG. 9. Case IV. Inspiration and expiration roentgenograms. Note the small left hilar shadow, the retention of radiolucency on the left side on expiration, shift of the mediastinum and decreased excursion of the left hemidiaphragm.

FIG. 10. Case IV. Left bronchogram showing widespread fusiform dilatation of most of the bronchi, with multiple bud-like projections and absence of alveolar filling.

bronchial tree appeared normal.

Bronchoscopy revealed the presence of thick white secretions within the left main bronchus. The left lower lobe bronchus appeared slightly narrowed and the left main bronchus opened into the trachea at more of a right angle than usual. A biopsy taken from the left lower lobe bronchus was reported as normal bronchial mucosa. Pulmonary function studies were performed in July, 1955. These were interpreted as showing evidence of generalized bronchial obstruction, along with a poor respiratory reserve (one-second timed vital capacity—48.5 per cent; maximum breathing capacity—32.3 per cent).

Following discharge, the patient has been followed at frequent intervals. He has been developing more frequent severe respiratory infections and has become progressively more dyspneic. Chest roentgenograms have shown no change.

CLINICAL, LABORATORY AND PATHOLOGIC FINDINGS

The cases presented in this study showed not only a uniform roentgen pattern, but also significant points of clinical similarity. All of the patients were white males, ranging in age from twelve to forty years. Two of the patients recalled episodes of foreign

body aspiration in childhood and dated their earliest symptoms to these events. The other 2 patients were the twelve year old with respiratory symptoms dating to the age of three and Case IV, who at forty had had symptoms of pulmonary disease at least through all of his adult life. Thus, all 4 cases gave a history of respiratory symptoms of many years' duration. Cough, expectoration and wheezing were complaints common to all. Exertional dyspnea and hemoptysis were noted by all but the youngster. In each patient physical examination revealed wheezing, râles and marked diminution of breath sounds over the involved lung.

Pulmonary function studies were performed in 3 of the patients. In 2 of these, the findings were consistent with an obstructive deficiency, the sort of picture seen in patients with ordinary asthma or emphysema. In the third patient there was no evidence of obstruction. This patient, on differential bronchospirometry, showed on the side of the lesion, normal ventilation with markedly subnormal oxygen uptake, a finding which was altered very little by surgical removal of the involved lobe.

Bronchoscopy was entirely normal in 3 of the patients while in the fourth there was thought to be slight narrowing of the involved lower lobar bronchus with considerable whitish secretion visible. This narrowing was not evident bronchographically.

In the single available pathologic specimen (Fig. 6) the abnormality appeared to lie mainly in the bronchi, where hyalinization of basement membranes, round cell infiltration, hyperplasia of smooth muscle, scarring and distortion were noted. Foci of emphysema were also present. The lobar pulmonary artery was described as normal. The pathologic findings were not specifically diagnostic.

ROENTGEN FINDINGS

The roentgen findings in these 4 patients were quite similar to each other and were characterized by several striking features. These included: (1) an abnormal degree of translucency of one lobe or lung; (2) normal or small size of the affected portion of the lung; (3) failure of the involved lobe or lung to expand and contract normally on respiratory movement, manifested by a shift of the mediastinum toward the affected side on inspiration and away from it on expiration, and by limitation of the excursion of the hemidiaphragm and rib cage on the involved side; (4) a small hilar shadow with sparseness of the intrapulmonary vascular markings on the more radiolucent side; and (5) a peculiar bronchiectatic pattern, demonstrable on bronchography, which is confined to the involved area.

The unilateral hyperlucency (Fig. 1, 4, 7 and 9) was the finding which first called attention to these cases and led to further study. In each case it appeared to be the result of both a deficiency in the vascular markings and an increase in air content. In 2 patients, the increased translucency was augmented by the presence of emphysematous bullae (Fig. 1 and 7).

The swing of the mediastinum in the direction of the hyperlucent side on inspiration and away from it on expiration and the limitation of motion of the diaphragm and rib cage indicated a more or less constant volume of the involved part of the lung during respiration. These findings are also seen in obstructive emphysema due to a check-valve mechanism in one of the large bronchi. In 3 cases the heart and other mediastinal structures were deviated slightly into the affected hemithorax on inspiration and even on expiration did not shift into the normal hemithorax (Fig. 1, 7 and 9). In the other patient (Fig. 4) the mediastinal structures moved into the normal hemithorax on expiration, and back to the midline on inspiration. These findings indicated that, on inspiration, the hyperlucent lung was smaller, or at least no larger, than the normal lung.

The apparent small size of the main pulmonary artery and the diminution of the

intrapulmonary vascular markings were clearly seen in the plain roentgenograms of all of the patients. These findings were confirmed by pulmonary angiography in one case (Fig. 3) and by laminagraphy in another.

The bronchographic findings were strikingly similar in all 4 cases (Fig. 2, 5, 8, *A* and *B*, and 10). The major bronchi were normally patent and the segmental branches normally distributed. Many of the smaller bronchi in the hyperlucent lung were mildly dilated and showed a beaded appearance. The ends of some of these bronchi were clubbed and occasionally small "buds," or smooth contrast-filled pockets projected from the sides or ends of the smaller divisions. There was almost a complete lack of alveolar filling. The overall roentgen appearance was distinctive. In contrast, the bronchograms of the opposite lung in each case appeared normal (Fig. 8*B*).

DISCUSSION

The many conditions which produce abnormal unilateral radiolucency of the lung must be considered in the differential diagnosis. These fall into three main categories: asymmetric chest wall, certain types of unilateral emphysema, and unilateral pulmonary undercirculation.

Asymmetry of the chest wall occurs in congenital absence of a pectoral muscle, in scoliosis, and following such surgical procedures as mastectomy. These are readily excluded by the clinical examination, the absence of mediastinal shift, and the normal appearance of the pulmonary vessels.

In unilateral obstructive emphysema secondary to a check-valve mechanism in a major bronchus (central obstructive emphysema), the lung is usually larger on the affected side than on the contralateral side, even on inspiration. However, this is not always the case, and size alone is not sufficient to distinguish central obstructive emphysema from idiopathic unilateral hyperlucent lung. Furthermore, the direction of mediastinal swing and the limitation of diaphragmatic movement are identical in the two conditions. Therefore, in order to exclude central obstructive emphysema, one must resort to bronchoscopy and bronchography. The demonstration of normal patency of the major bronchi excludes the presence of central obstructive emphysema.

Congenital lobar emphysema, a number of cases of which have been reported in the literature, is nearly always encountered in infants.[3,6,9,20,22] The affected lobe is considerably enlarged. The condition is generally attributed to a check-valve type of obstruction of the lobar bronchus, but in a number of cases no etiologic factor has been demonstrated. The emphysema is usually progressive, although spontaneous regression has been known to occur. This condition is differentiated from idiopathic unilateral hyperlucent lung by the age of the patient, the evidence (when present) of partial obstruction of the bronchus, and the progressive enlargement of the affected lobe. The abnormal bronchial pattern described in our cases has not been reported in congenital lobar emphysema.

The common varieties of diffuse or bullous emphysema may at times be predominantly or completely unilateral. Since 2 cases in the present series showed bullae, and since mediastinal shift, limitation of diaphragmatic motion and unilateral decrease in hilar and vascular markings also occasionally occur in cases of ordinary unilateral emphysema, differentiation from idiopathic unilateral hyperlucent lung rests on bronchography. While unilateral bronchographic abnormalities may occur in chronic emphysema, spreading of the bronchi, arcuate patterns around bullae, and attenuation and elongation of smaller branches give a picture unlike that seen in the bronchograms of our patients.

Compensatory emphysema of pulmonary tissue adjacent to a collapsed or contracted portion of lung is usually readily excluded by the demonstration of the radiopaque collapsed lobe or segment and by the vertical displacement of the hilus and other signs

of collapse. If the diagnosis is in doubt, bronchography will provide the ultimate differentiation by showing the abnormal distribution of the bronchi. Congenital hypogenesis or agenesis of a lobe may be quite difficult to exclude on plain roentgenograms, but is also readily differentiated by bronchography.

Idiopathic unilateral hyperlucent lung must also be distinguished from unilateral alteration in the pulmonary vasculature, such as occurs in thrombosis or embolism of a large pulmonary artery, or in congenitally absent or hypoplastic pulmonary artery.

Thrombosis or embolism of a large pulmonary artery may result in diminished vasculature and thereby increased radiolucency.[7,10] However, the mediastinal structures are usually not displaced and the pulmonary artery shadow on the affected side is generally larger than normal. There is no mediastinal swing with respiration. These roentgen findings, coupled with the clinical and electrocardiographic evidence, facilitate differentiation from idiopathic unilateral hyperlucent lung.

Congenital absence of a main pulmonary artery often results in a small hemithorax with displacement of the mediastinal structures toward the affected side, a small or absent hilar shadow, and marked decrease in the pulmonary vascular markings.[1,13–16,18,23] Usually the normal lung is overexpanded and appears more radiolucent than the affected lung. Other cardiac anomalies are often present. Bronchography is usually normal, although one reported case showed cystic bronchiectasis on the side of the absent pulmonary artery.[18] Differential bronchospirometry reveals approximately equal air exchange in the two lungs, but marked impairment or absence of oxygen uptake on the affected side, a finding identical to that in Case II of our series. It is evident that the findings in absent pulmonary artery may resemble those of our cases. Final differentiation between the two conditions rests on bronchography and pulmonary angiography.

The question of separating idiopathic unilateral hyperlucent lung from the entity of hypoplasia of a pulmonary artery deserves particular consideration. There is no doubt that all of our patients appear to show unilateral deficiency in pulmonary arterial circulation. Furthermore, as previously noted, several cases similar to ours have been reported in the literature under the heading of pulmonary artery hypoplasia.[2,5,8,11,21] It could be maintained that the entire picture of the condition which we are reporting essentially represents primary hypoplasia of a main pulmonary artery, with emphysema and mild bronchiectasis being the result of associated infection. This point of view assumes a second mechanism, superimposed infection, to explain the pulmonary changes. It seems to us that a better case can be made for considering the circulatory changes the result of the other pulmonary abnormalities, or attributing *all* of the findings to some more fundamental disorder of growth and development of the lung and its circulation.

The problem is complicated by the fact that the diagnosis of hypoplasia of a pulmonary artery is very difficult. Obviously, smallness of a pulmonary artery as noted on a plain chest roentgenogram or even on an angiogram does not necessarily mean hypoplasia. Patients who suffer from ordinary emphysema or other chronic lung disorders often show a small pulmonary artery with sparse branches on angiocardiography. In Case II of our series (the patient whose right lower lobe was removed), the pulmonary artery was described as normal at operation, although the chest roentgenograms had shown an apparent deficiency in the circulation of the involved lobe. Swyer and James' patient had a larger pulmonary artery at surgery than was suspected from the preoperative angiogram.[19] We have had the opportunity recently of studying another patient, not included in the present series, who had a very small hilar shadow on the right side, but whose pulmonary artery was normal at autopsy. With these cases in mind, it is clear that there are many pitfalls in the diagnosis of

primary hypoplasia of a pulmonary artery.

Considering these factors, then, we believe that hypoplasia of a pulmonary artery is probably a separate entity from idiopathic unilateral hyperlucent lung; however, we would agree that until there is further knowledge of the pathogenesis and etiology of these conditions, an absolute differentiation between them may not be possible.

The nature of the emphysematous process in our patients is not clear. However, the striking lack of alveolar filling in each case suggests that there may be widespread obstructive processes in the small peripheral bronchi. If this is true, the emphysema could be explained on the basis of multiple check-valve mechanisms associated with this type of obstruction. The presence of bullae in 2 cases supports this concept.

The history of foreign body aspiration in 2 of the 4 cases is interesting but difficult to evaluate. Certainly there is no evidence at the present time of any obstruction which could be attributed to a foreign body.

The radiologist is in an excellent position to contribute to the further understanding of idiopathic unilateral hyperlucent lung, since the recognition and work-up of patients with this syndrome are largely in his hands. By calling the attention of the clinician and the pathologist to such cases, he may encourage correlative studies which can lead to a more complete comprehension of this disease.

SUMMARY

Four cases of a roentgenologic syndrome characterized by unilateral emphysema, a peculiar form of bronchiectasis, and pulmonary arterial undercirculation are presented. The chief roentgen features include the following: (1) abnormal translucency of an entire lung or lobe; (2) normal or small size of the affected lung or lobe; (3) maintenance of almost constant volume of the affected portion of the lung during changes in respiration; (4) a small hilar shadow with sparseness of the intrapulmonary vascular markings; and (5) an unusual bronchiectatic pattern without evidence of obstruction of the larger bronchi.

The clinical and laboratory aspects of this condition indicate that it is associated with a disability of varying degree, perhaps related to impairment of pulmonary function. Differentiation of this syndrome from other conditions causing abnormal unilateral radiolucency can be made, bronchography being of particular value in this regard. Pulmonary artery hypoplasia presents the most difficult problem in differential diagnosis.

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REFERENCES

1. Alexander, S. C., Figiel, S. J., and Class, R. N. Congenital absence of left pulmonary artery. *Am. Heart J.*, 1955, *50*, 465–470.
2. Belcher, J. R., and Pattinson, J. N. Hypoplasia of the lobar pulmonary arteries. A report of three cases. *J. Thoracic Surg.*, 1957, *34*, 357–364.
3. Cottom, D. G., and Myers, N. A. Congenital lobar emphysema. *Brit. M. J.*, 1957, *1*, 1394–1396.
4. Dornhorst, A. C., Heaf, P. J., and Semple, S. J. G. Unilateral "emphysema." *Lancet*, 1957, *2*, 873–875.
5. Elder, J. C., Brofman, B. L., Kohn, P. M., and Charms, B. L. Unilateral pulmonary artery absence or hypoplasia. Radiographic and cardiopulmonary studies in five patients. *Circulation*, 1958, *17*, 557–565.
6. Fischer, H. W., Lucido, J. L., and Lynxwiler, C. P. Lobar emphysema. *J.A.M.A.*, 1958, *166*, 340–345.
7. Hanelin, J., and Eyler, W. R. Pulmonary artery thrombosis: Roentgen manifestations. *Radiology*, 1951, *56*, 689–703.
8. Heier, H. Zur Kenntnis des Röntgenbildes der einseitigen Pulmonalishypoplasie. *Deutsche Gesundhwes.*, 1956, *11*, 626–629.
9. Holzel, A., Bennett, E., and Vaughan, B. F. Congenital lobar emphysema. *Arch. Dis. Childhood*, 1956, *31*, 216–221.
10. Keating, D. R., Burkey, J. N., Hellerstein, H. K., and Feil, H. Chronic massive thrombosis of pulmonary arteries; report of seven

cases with clinical and necropsy studies. AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED., 1953, *69*, 208–220.

11. LAUR, A., and WEDLER, H. W. Die einseitig helle Lunge im Röntgenbild. *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, 1955, *82*, 305–315.
12. MACLEOD, W. M. Abnormal transradiancy of one lung. *Thorax*, 1954, *9*, 147–153.
13. MADOFF, I. M., GAENSLER, E. A., and STRIEDER, J. W. Congenital absence of the right pulmonary artery; diagnosis by angiocardiography with cardiorespiratory studies. *New England J. Med.*, 1952, *247*, 149–157.
14. MAIER, H. C. Absence or hypoplasia of a pulmonary artery with anomalous systemic arteries to the lung. *J. Thoracic Surg.*, 1954, *28*, 145–162.
15. MCKIM, J. S., and WIGLESWORTH, F. W. Absence of the left pulmonary artery; a report of six cases with autopsy findings in three. *Am. Heart J.*, 1954, *47*, 845–859.
16. MOSS, A. J., AUSTIN, W. O., and O'LOUGHLIN, B. J. Congenital absence or atresia of a main branch of the pulmonary artery. *A.M.A. J. Dis. Child.*, 1956, *92*, 398–402.
17. SLUTZKER, B., SHAW, W. R., and TOMASHEVSKI, J. Localized non-functioning lung. To be published.
18. STEINBERG, I. Congenital absence of a main branch of the pulmonary artery; report of three new cases associated respectively with bronchiectasis, atrial septal defect and Eisenmenger's complex. *Am. J. Med.*, 1958, *24*, 559–567.
19. SWYER, P. R., and JAMES, G. C. W. A case of unilateral pulmonary emphysema. *Thorax*, 1953, *8*, 133–136.
20. VAN EPPS, E. F., and DAVIES, D. H. Lobar emphysema. AM. J. ROENTGENOL., RAD. THERAPY & NUCLEAR MED., 1955, *73*, 375–386.
21. VAUGHAN, B. F. Syndromes associated with hypoplasia or aplasia of one pulmonary artery. *J. Fac. Radiologists*, 1958, *9*, 161–168.
22. WILLIAMS, M. H. Localized pulmonary hypertrophic emphysema. *J. Thoracic Surg.*, 1952, *24*, 522–529.
23. WYMAN, S. M. Congenital absence of a pulmonary artery; its demonstration by roentgenography. *Radiology*, 1954, *62*, 321–328.

PULMONARY ALVEOLAR PROTEINOSIS

REPORT OF TWO CASES

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"We see only what we look for; we recognize only what we know."[7]

THESE cases of pulmonary alveolar proteinosis are reported to add to the available case material, to call the attention of radiologists to the condition, and to point out the key role of roentgenography in the diagnosis. In neither of these cases was the diagnosis made prior to thoracotomy because we did not know what to look for and did not recognize what we saw. The diagnosis can be confirmed only by histologic examination of the involved lung, but there are few conditions in which such extensive pulmonary changes are demonstrated by roentgenography, associated with such a paucity of physical findings.

Pulmonary alveolar proteinosis, an apparently new disease, was first described by Rosen and his associates[5] in June, 1958. The name of the disease is a misnomer in that the intra-alveolar substance is not a protein, but until the substance is accurately identified, the name will remain.

Since the etiology of the condition is unknown, proof is lacking that it is a completely new disease. Past experience should make one wary of accepting as absolutely new any disease or condition in which the etiology has not been established. The usual course is to have the new entity discovered, either clinically or at autopsy, and thoroughly described. A causal factor may even be erroneously identified, only, perhaps years later, to have some facet of the disease discovered which proves it to be merely a variant of a previously known condition. There is little doubt, however, that the histologic changes in alveolar proteinosis were not observed in any cases prior to 1953 by any of the many pathologists who have had occasion to view the tissue sections from the reported cases.

The data on 27 patients, collected from several sources, were presented by Rosen *et al.*[5] Plenk and his associates[3] presented additional material on 2 of the patients in that series and reviewed a third case which had been previously reported prior to the identification of this disease entity.[4] The authors' cases bring to a total of 30 the number of patients reported to have pulmonary alveolar proteinosis. Whether this is a new disease, or one not recognized previously, it has been encountered with increasing frequency since 1953, and it very well may be more common than the recorded number of cases would suggest.

REPORT OF CASES

CASE 1. Negro male, aged twenty-three. The past history was negative except for measles in childhood. There was no evidence of pulmonary symptoms or pulmonary disease exposure. The occupational history was completely negative. The patient was a student prior to induction into the Air Force in 1954, and served in the Air Police. He was born in Memphis, Tennessee, and moved to St. Louis at the age of five years. He served in Texas, California and Japan, and felt that he was in perfect health when he returned to the United States in December, 1957. A routine chest roentgenogram at that time (Fig. 1*A*) showed extensive, patchy, irregular, confluent and feathery densities, distributed bilaterally, predominantly in the lower lobes. A chest roentgenogram taken in 1954 was clear. He had no complaints but was immediately hospitalized. Physical examination disclosed

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essentially normal findings on repeated occasions by several examiners.

Extensive laboratory studies were all normal or negative. Coccidioidin skin tests were negative in December, on admission, and in January and April. Positive reactions were obtained at these times with histoplasmin and purified protein derivative no. 1. Serologic studies yielded mixed reactions in varying titers so that the results were not considered contributory in this specific case.

The patient was transferred to the Fitzsimons Army Hospital in April, 1958. He was without complaints and remained so until just prior to thoracotomy in July, 1958, when he first became aware of shortness of breath on exertion. This was surprising since pulmonary function studies in April and May showed a severe degree of pulmonary insufficiency, ventilatory in type, restrictive in nature, with loss of lung volume.

Various conditions considered in the differential diagnosis were tuberculosis, fungus disease, sarcoidosis and eosinophilic granuloma. Although no acid-fast organisms were ever recovered, the patient was given a trial of antituberculosis therapy because of the positive purified protein derivative reaction. There were no significant roentgenographic changes (Fig. 1, *A* and *B*) in the seven months from December, 1957 to July, 1958.

A thoracotomy for lung biopsy was performed on July 24, 1958. The recovery was uneventful except that the patient complained of increasing shortness of breath. This was confirmed by repeated pulmonary function studies which showed progressive pulmonary insufficiency. No other symptoms developed and the patient maintained his weight. Serial roentgen studies to October, 1958 demonstrated no real change in the extent or character of the parenchymal lesions.

Case II. White female, aged forty. This patient had a flu-like illness in February, 1958, with generalized aches and pains, low-grade fever and cough. She had one episode of epistaxis and noted blood in the sputum. She was treated symptomatically and with bed rest for a period of one week. Ease of fatigue and

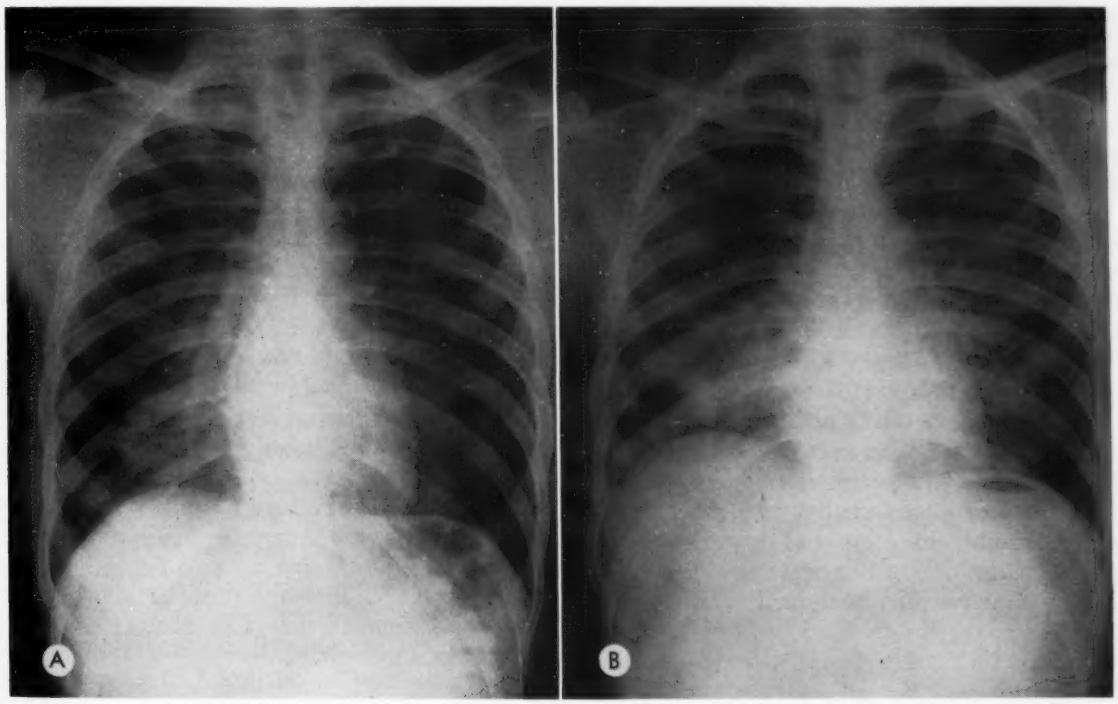

Fig. 1. Case 1. (*A*) Routine chest roentgenogram taken in December, 1957. The patient was asymptomatic but immediately hospitalized. Note extensive, diffuse, feathery pulmonary densities predominating in the lower lung fields. (*B*) Posteroanterior roentgenogram of the chest in July, 1958. Note that the extent of involvement is essentially unchanged. The change in pulmonary densities is more apparent than real and contributed to, in part, by the difference in the respiratory phase in the two studies.

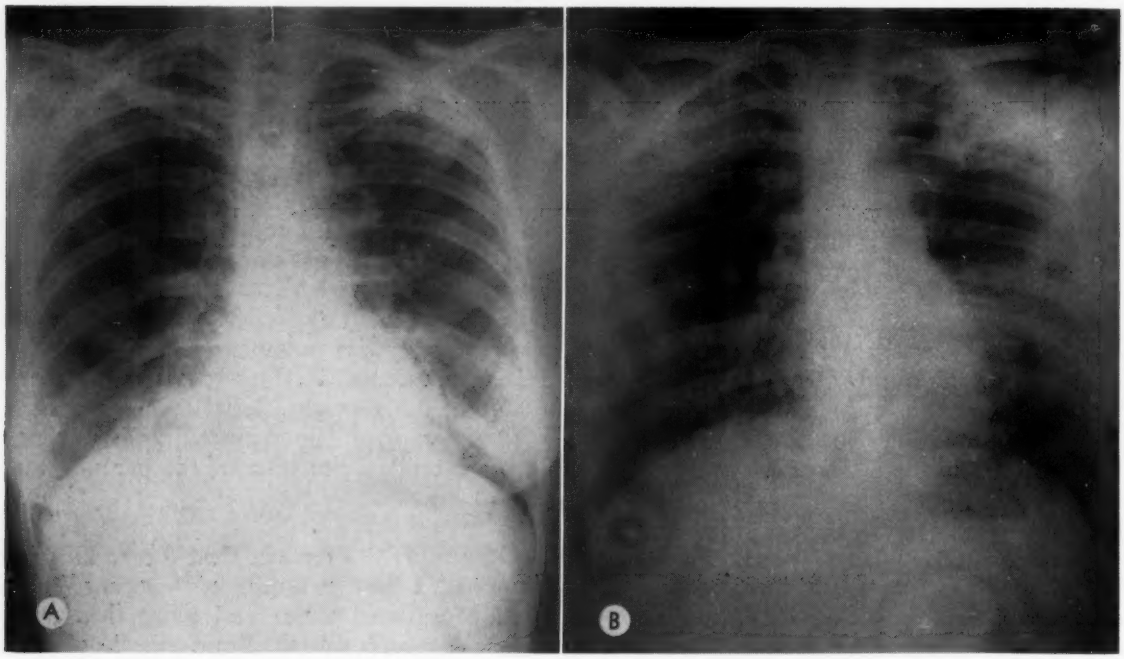

FIG. 2. Case II. (*A*) Posteroanterior roentgenogram of the chest taken in March, 1958. Note the large cavitary lesion in the left apex and the feathery densities throughout both lungs but predominantly in the basal areas. (*B*) Roentgenogram in the apical lordotic projection on the same date shows more clearly the two grossly different lesions.

epistaxis continued, and a roentgenogram of the chest on March 5 revealed an infiltration, with cavity, in the left upper lobe. There were also feathery, and granular confluent densities noted in both lung fields, more prominent toward the bases. A routine chest roentgenogram in July, 1957 showed normal findings. The patient was a housewife by occupation who had resided in Mississippi, Florida, Texas, Maryland, Okinawa, and Texas.

Fever rising to 100.4°F. was present on admission to the hospital. The physical examination disclosed essentially normal findings except for a few sticky rales over the left apex, with no abnormality in percussion or fremitus. The laboratory findings were likewise in the normal range. The bacteriologic studies were negative. A histoplasmin skin test was not done. Coccidioidin and purified protein derivative no. 1 were negative; the purified protein derivative no. 2 was two-plus. Although no organisms were found on smear or culture, the patient was transferred to the Fitzsimons Army Hospital for antituberculosis therapy.

The physical findings and laboratory data were still not contributory. The histoplasmin skin reaction was two-plus. Frontal and apical lordotic roentgenograms of the chest (Fig. 2, *A* and *B*) showed infiltration and cavitary disease in the left apex, and densities disseminated in the other portions of the lungs. The patient showed clinical improvement on antituberculosis drugs, but a chest roentgenogram (Fig. 3) failed to show significant change in the disseminated densities after a three-month interval, and the cavity was still felt to be present in the left apex, although less apparent. Old endobronchial disease, with scarring, was reported on bronchoscopy, but biopsy was unsuccessful. A scalene lymph node was reported as showing reactive hyperplasia. The patient underwent thoracotomy on September 8, 1958.

The postoperative course was uneventful. Exertional dyspnea had not, as yet, been a feature of this case. Antituberculous drugs were continued even though no acid-fast organisms were ever found, and in spite of the fact that the histopathologic picture did not resemble a tuberculous process.

PATHOLOGY

Examination of fresh tissue smears and special fixed tissue sections from both cases failed to reveal any causative organisms.

A single wedge of tissue from the right middle lobe and a lymph node from just

beneath the right upper lobe bronchus were removed in Case I. In Case II, wedges were removed from the apical posterior segment of the left upper lobe and from the lingula, also a lymph node adjacent to the mediastinum. The lymph node changes in both cases were nonspecific, being reported as chronic lymphadenitis and reactive hyperplasia.

Changes described as characteristic of pulmonary alveolar proteinosis were present in the specimen obtained from Case I and in the wedge from the lingula in Case II. In both cases, there were patchy, confluent areas of a granulomatous-like process, without evidence of discrete nodules or of caseation, and with interspersed areas of grossly normal lung parenchyma. Histologically, there was a patchy, alveolar filling process (Fig. 4, *A* and *B*) with the material consisting of a granular acidophilic substance. This material was PAS-positive. The interalveolar septa were not involved *per se*, but proliferation of large cells, somewhat like lipophages, was noted from the alveolar walls. These were interpreted as septal cells, and granules within their cytoplasm were also PAS-positive. The appearance in Case II varied somewhat in that there was also evidence of a diffuse vesicular emphysema. In addition, the septal cells were more numerous, suggesting an earlier phase than that seen in Case I.

The fixed tissue sections from the apical posterior segment of the left upper lobe in Case II showed a diffuse, chronic inflammatory process with interstitial fibrosis but with no evidence of granulomatous formation. In some areas, the remaining alveoli showed accumulations of cells similar to the septal cells seen in the lingular specimen, with PAS-positive granules within their cytoplasm. The histologic changes in this lung segment, by themselves, would not warrant a diagnosis of pulmonary alveolar proteinosis.

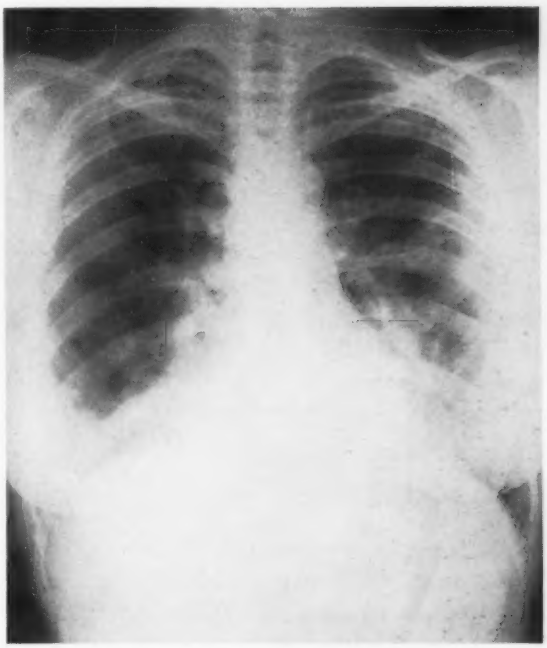

Fig. 3. Case II. Posteroanterior roentgenogram of the chest three months after Figure 2. The reaction about the cavity in the left apex has cleared, but the cavity is still present. The disseminated parenchymal densities appear to be unchanged. Again, differences in technique were felt to explain the apparent increase, since roentgenograms before and after this date failed to demonstrate any change from the original study.

DISCUSSION

According to Rosen and his associates,[5] it is the presence of the PAS-positive granular proteinaceous material within the lumina of the distal air spaces, with little or no thickening of the interalveolar septa, which is characteristic of the histopathology of pulmonary alveolar proteinosis. Plasma cells are not a part of this picture. It is felt to be fairly well established that the proteinaceous material is formed through a transformation of proliferated "septal cells." These are large mononuclear cells in the interalveolar septa which subsequently slough into and necrose in the distal air spaces. Also present are acicular crystals and variable, intensely staining laminated bodies which are believed to be cellular fragments. Not all of these elements are present in all sections at the same time, but will vary depending upon the stage of the disease. It is thought that the presence of septal cells is indicative of a fairly early phase. In older lesions, septal cells are rare, and more of the laminated cellular fragments are seen.

Fig. 4. (*A*) Low power photomicrograph showing patchy alveolar filling process (H. and E. stain; ×145). (*B*) High power view. Note alveoli filled with proteinaceous material. Proliferation of septal cells can be seen. The interalveolar septa are otherwise essentially normal (H. and E. stain; 4× Micro-Tessar).

Rosen *et al.*[5] point out that the ultimate fate of these lesions is difficult to establish at this time since serial tissue sections are not available for this evaluation. They note that the general absence of reaction in the interalveolar septa suggests the possibility of resolution, but they also report roentgenographic evidence of fibrosis in some instances.

The PAS-positive reaction of the intra-alveolar material has, among other factors, suggested a relationship to *Pneumocystis carinii* pneumonitis, also called plasmacellular interstitial pneumonitis. The histopathology is otherwise dissimilar. Rosen and his associates[5] hasten to point out that the findings in alveolar proteinosis may represent a different stage or some peculiarity of response on the part of particular hosts to the organism, and that a reliable serologic test for pneumocystis infection would be of value. Plenk *et al.*[3] reported that a serologic test for pneumocystis pneumonia, as yet unproved, has been developed in

Europe, and that a positive reaction was obtained with the serum from one of their patients with alveolar proteinosis who was given this test. Obviously, this has stimulated additional investigative efforts, but the existence of *Pneumocystis carinii* pneumonitis in other than premature or debilitated infants is still open to question,[2] and the reported relationship to cytomegalic inclusion disease is uncertain.[1,6]

There are other features in common to plasmacellular pneumonia and pulmonary alveolar proteinosis, but they neither prove nor disprove a relationship. There is an insidious onset of both diseases, both have extensive roentgenographic changes with very little in the way of positive findings on auscultation, and the mortality rates are approximate on the basis of current information. Only 8 deaths in the 27 patients are noted in the original report, but Plenk[4] states that, through an oversight, the death of their second case was not included in that report. The third case in the series of Plenk and his co-workers,[3] which has not yet reached the literature, also died. It is probable that there have been additional deaths among the original 27 patients since, at the time of publication of the report, several had shown evidence of progression of their disease, both clinically and by roentgenography. The most convincing argument against pneumocystis infection and alveolar proteinosis being related is the failure to identify a causative organism in the latter condition.

Other conditions to which consideration was given as being possibly related to alveolar proteinosis were the type-reaction observed after exposure to fumes of various metals, such as mercury, cadmium and beryllium. No evidence of these metals has ever been found when search was made. Also, there has been noted a similarity to certain immune reactions in other tissues. Rosen *et al.*[5] point out that such a reaction might take place in the lung in response to an unidentified inhalant, but that this assumes that the agent itself remains in the environment for long periods and in widely separated localities. It was also considered that alveolar proteinosis might represent an early stage of microlithiasis alveolaris. There is a difference in distribution of the lesions in the latter condition,[7] and, further, none of the cases of alveolar proteinosis has been observed to develop calcification.

The clinical manifestations of pulmonary alveolar proteinosis are quite variable, and they may additionally be complicated by superimposed bacterial or fungal infection. This was noted in several of the cases in the original series. The authors' first case is unusual in that it is the only one, with possibly the exception of Case 9 in the series of Rosen *et al.*,[5] in which roentgenographic changes were discovered prior to onset of symptoms. On the basis of a single case, conclusions are not warranted, but in this instance, at least, the pathologic process, whatever its nature, produced extensive changes before the patient became aware of any disability. In previous cases an exact date of onset was difficult to establish. In several there was a premonitory febrile illness, but in most patients there was an unheralded and creeping progressive dyspnea with cough, which was usually productive. Other presenting symptoms noted were fatigability, chest pain and loss of weight.

ROENTGEN FINDINGS

The roentgen changes in all cases have been strikingly similar for the same phases of the illness. The characteristic appearance is said to be that of a fine granular or feathery type of parenchymal density, soft in appearance, usually widely disseminated, and resembling severe pulmonary edema in its radial distribution from the lung hili. This radial distribution was not especially apparent in either of the authors' cases. Rather, the densities tended to be increased in number and to be more confluent toward the lung bases. In Case 11, it is probable that the changes seen in the left apex are not a feature of pulmonary alveolar proteinosis, but represent a coexistent, unre-

lated disease process. The histopathologic evidence is that the earliest changes of alveolar proteinosis were making their appearance at the time the specimen was obtained, and they do not correspond with the duration and extent of disease shown on roentgenograms. This may be an invalid conclusion based on inadequate knowledge of the true nature of pulmonary alveolar proteinosis.

The roentgen changes in this condition also bear some resemblance to those of sarcoidosis, but hilar adenopathy is not a feature. In addition, in no instance, in a review by one of the authors (Lull) of over 170 cases of pulmonary sarcoidosis at this hospital, has the sarcoid lesion of this type been noted to be so constantly unchanging over such long periods.

The roentgen differential diagnosis could include a wide range of possibilities, but the key, assuming adequate quality of the roentgenograms, is the striking absence of positive physical findings in the presence of extensive changes in the lungs noted on the roentgenograms. There are relatively few other conditions in which this oddity is noted, and the correlation of the clinical information with such roentgen characteristics as the density of the individual lesions, their distribution, associated hilar changes, etc., will readily eliminate most from consideration.

Already mentioned is the similarity to pulmonary alveolar microlithiasis. In this, the lesions are of calcific rather than soft tissue density, and they are much more uniform in their distribution in all lobes of both lungs. In stannosis, the changes are due to deposits of tin oxide, and the lesions are of metallic density. The lesions in berylliosis show a more uniform distribution and individually are larger and definitely more nodular. The patient may be without symptoms in each of these conditions. In hemosiderosis, the distribution of the lesion differs, and the cardiac findings should aid in the diagnosis. There are many other conditions which would cause difficulty in differential diagnosis on the basis of roentgenographic findings alone, but when the clinical aspects are correlated, the problem is simplified.

The fate of the roentgen pulmonary changes, in common with the histologic changes, has not yet been determined. The pulmonary lesions may remain remarkably unchanged, as was noted in the authors' cases, over periods of months or years, and unrelated to changes in symptomatology. They may also show progression, becoming more extensive in distribution and more confluent. Resolution, when it occurs, is said to begin at the periphery and progress toward the hilus.

In only one patient in the original series (Rosen and co-workers' Case No. 19) was there concomitant resolution of the roentgen changes as evidence of complete clinical recovery. Additional history reported by Plenk and his associates[3] on one of their cases is worthy of note. The disease in their patient was apparently more localized than is usual since clinical recovery followed resection of the lingula and superior segment of the left lower lobe.

In previously reported cases, some clearing on roentgenograms was reported in 5 of 28 patients, and about an equal number showed progression. The remainder evidently showed little or no change in roentgen findings. Since this is a chronic disease, most patients have not been observed for a sufficiently long period for this stability of the pulmonary lesion to be adequately evaluated. There may be histologic changes of importance but not of a degree to be manifested by roentgen changes. Certainly, there appear to have been patients who showed symptomatic improvement, others with a worsening of their symptoms, and still others who progressed to death without reported marked change roentgenographically.

TREATMENT

There are no reports of therapeutic measures which have been of value in treatment of the specific disease. Antibiotics and steroids have been tried, but Rosen and his

associates[5] felt that secondary infection may have been abetted by their prolonged use and that these drugs should be reserved for superimposed acute bacterial infections.

It would seem that the rationale of treatment will depend upon either discovery of the etiologic factor of alveolar proteinosis, which is, as noted earlier, a misnomer, or identification of the substance found in the alveoli. Efforts to identify this substance have not, so far, been successful except to demonstrate that it is not a pure protein. Studies with histochemical stains at the United States Army Research and Development Unit, Fitzsimons Army Hospital, on material from the 2 cases presented here resulted in the conclusion that the intra-alveolar material contained some mucin and was composed of considerable quantities of lipoid material interspersed with amino acid and nucleic acids. True proteins, which should be evidenced by the presence of sulfhydryl or disulfide linkages, were not present.

Death, when not the result of superimposed infection, is the result of obliteration of the respiratory surface. Cor pulmonale was present in one patient reported by Rosen *et al.*[5] and in that instance there was a superimposed necrotizing nocardiosis. Cor pulmonale was also found in the second case of Plenk and his associates.[3]

If the specific alveolar filling substance can be identified, then efforts may be directed toward alteration of the *in vivo* environment to prevent its accumulation, or to dissolution of the coagulum so that the material may be expectorated. This is not a simple problem since there is a high lipid content in the material, and current investigative efforts in this direction have not been fruitful.

SUMMARY AND CONCLUSIONS

Two cases of an apparently new disease, pulmonary alveolar proteinosis, have been reported, not only to add to the available case material but to call to the attention of radiologists their key role in its identification.

The etiology of the condition is unknown. Whether it is a truly new disease has not been established, but it appears not to have been present prior to 1953, and it has been recognized with increasing frequency since then. The possibility that it is a bizarre form of an already known disease is discussed.

The points in the differential diagnosis are enumerated. While histopathologic examination is required to confirm the diagnosis, pulmonary alveolar proteinosis may be suspected in a patient who shows extensive roentgen pulmonary changes in the presence of essentially normal findings on physical examination of the chest.

Since pulmonary alveolar proteinosis is being met with increasing frequency, since it is a chronic disease, and since there appears to be a high mortality rate, the search for the etiologic agent and for adequate therapeutic measures must be pressed with vigor.

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REFERENCES

1. Baar, H. S. Interstitial plasmacellular pneumonia due to *Pneumocystis carinii*. *J. Clin. Path.*, 1955, *8*, 19–24.
2. Hamperl, H. Pneumocystis infection and cytomegaly of lungs in newborn and adult. *Am. J. Path.*, 1956, *32*, 1–14.
3. Plenk, H. P., Swift, S. A., Chambers, W. L., and Peltzer, W. E. Pulmonary alveolar glycoproteinosis (pneumocystis pneumonitis?). To be published.
4. Plenk, H. P. Personal communication.
5. Rosen, S. H., Castleman, B., and Leibow, A. A. With collaboration of Enzinger, F. M., and Hunt, R. T. N. Pulmonary alveolar proteinosis. *New England J. Med.*, 1958, *258*, 1123–1142.
6. Russell, H. T., and Nelson, B. M. Pneumocystis pneumonitis in American infants; report of two cases, with autopsy studies. *Am. J. Clin. Path.* 1956, *26*, 1334–1340.
7. Sosman, M. C., Dodd, G. D., Jones, W. D., and Pillmore, G. U. Familial occurrence of pulmonary alveolar microlithiasis. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1957, *77*, 947–1012.

THE EFFECTS OF BARIUM SULFATE ON THE LUNGS*

A CLINICAL AND EXPERIMENTAL STUDY

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MOST radiologists at this institution regard barium sulfate as an essentially inert, nontoxic material, harmless to the lungs. Not all of our clinical colleagues, however, share this opinion. On occasion, the fear of possible aspiration of barium sulfate has prevented the proper performance of necessary roentgen diagnostic procedures. On other occasions, when aspiration of barium sulfate has occurred, considerable concern has been expressed regarding possible complications and proper treatment.

A search of the literature to attempt to clarify this issue revealed that insufficient evidence on this subject is available. In the radiologic literature, nothing at all relative to this question has appeared for many years. Presumably this reflects a generally accepted belief among radiologists that aspiration of barium sulfate is a relatively innocuous incident. On the other hand, several recent papers devoted to other subjects have mentioned the dangers of aspiration of barium sulfate[23] or the toxic effects of barium sulfate.[9] None of these reports has included supporting evidence or discussion of these statements. In fact, we have been unable to establish the origin of the opinion that barium sulfate is toxic to the lungs. It seems possible that this is one of medicine's "old wives' tales" that arose from early experiences in radiology when a number of patients were poisoned by soluble barium salts that were erroneously substituted for barium sulfate[21,27] or present as impurities in improperly refined barium sulfate.[12]

Another question that has not previously been studied adequately is the mechanical effect of barium sulfate in the lungs. The significance of this question has been given added impetus by recent proposals to use barium sulfate as a bronchographic medium.[11,19,24] In view of these considerations a clinical and experimental study of the effects of barium sulfate on the lungs was undertaken. All the cases of aspiration of barium sulfate available from the files of the Department of Radiology of The Johns Hopkins Hospital were reviewed. Then the effects of intratracheal instillation of barium sulfate in a series of twenty dogs were studied.

REVIEW OF THE LITERATURE

Fishel[15] reported a case of a woman who aspirated several hundred cubic centimeters of a barium sulfate-water mixture with no apparent ill effects. Follow-up examination at four months revealed no changes except the presence of residual barium sulfate in the lung bases. Sullivan[25] reported a case of vomiting and aspiration of barium sulfate mixed with stomach contents. The patient, already markedly debilitated, died a few hours thereafter. The author believed that the aspirated barium sulfate facilitated the death of the patient.

Barium Pneumoconiosis. Arrigoni[3] reported an increased incidence of acute respiratory infections in barite miners. Feci[14] found pneumoconiosis in a considerable percentage of a group of barite miners. He observed no predisposition to tuberculosis, and he questioned Arrigoni's findings. Camba[6] reported no roentgenologic evidence of pneumoconiosis in a group of 14 men employed in mining, grinding, and sacking barium sulfate for periods of two to

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twenty-four years. Pendergrass and Greening[22] reported a pathologic study of a case of barium pneumoconiosis. The patient, who died from other causes, had pulmonary deposition of barium sulfate of many years' duration. Clinically there was no respiratory incapacity. Pathologically there were demonstrable barium sulfate crystals in the pulmonary tissue and no evidence of fibrosis. Pendergrass classified baritosis as a "benign" pneumoconiosis.

Effects of Barium Sulfate on the Peritoneum and Other Tissues. Foreign body granulomata after perforation of the intestine during barium studies have been reported by several authors.[17,20,26] Elliott and Rosenberg[13] observed ureteral occlusion from fibrosis following retroperitoneal extravasation of barium sulfate during a barium enema examination. Beddoe and co-workers[5] described a foreign body granuloma in the rectal wall caused by barium sulfate. They reviewed the literature and concluded that there was general agreement that small amounts of barium sulfate may remain indefinitely in the peritoneal cavity without local complications or signs of toxicity. Kleinsasser and Warshaw[18] studied the effects of intraperitoneal injection of barium sulfate in animals. Barium sulfate mixed with feces caused inflammation, adhesions, and usually death, but sterile barium sulfate alone caused no ill effects. Ané and Menville[2] reported cyst formations around unabsorbed barium sulfate injected subcutaneously in animals. They observed essentially no inflammatory reaction and concluded that barium sulfate was a virtually nontoxic foreign body which remained unabsorbed because the particles were too large to be phagocytized. Adolph and Taplin[1] injected intravenously in rabbits an aqueous suspension of micropulverized barium sulfate in dosage of 0.5 gm. per kilogram of body weight. No immediate or delayed toxic reactions were encountered.

Experimental Studies of Barium Sulfate in the Lungs of Animals. Arrigoni[4] injected barite ore and pure barium sulfate intratracheally into rats and rabbits. He reported histologic findings of a foreign body reaction including fibrosis and tubercle formation. Huston and co-workers[16] studied the effects of endotracheal injection of barium suspensions in rats. They observed very little cellular reaction and no fibrosis. They concluded that "barium sulfate is a relatively inert substance in the tissues and gives rise to only a very mild reaction." Cember and his co-workers[7,8] exposed rats to barium sulfate dust as a control for a study of the effects of radioactive barium sulfate dust. In the former group they found no pulmonary changes not also present in a "normal" control group, exposed to no dust.

Barium Sulfate Bronchography. Krisan *et al.*[19] and Sari *et al.*[24] reported satisfactory results with experimental barium sulfate bronchography in animals. DeRienzo and Duarte[11] reported clinical use of a barium sulfate-carboxymethyl cellulose mixture for bronchography. They stated that this preparation was less toxic than lipiodol or the absorbable media, and usually left no opaque residue in the lungs.

REVIEW OF CASES OF ASPIRATION OF BARIUM SULFATE

Sixteen cases of aspiration of barium sulfate were collected from the files of the Department of Radiology of The Johns Hopkins Hospital. It is possible that some cases were overlooked as it is not the routine practice to enter in the department index all uncomplicated cases of aspiration of barium sulfate. Included in the series are 5 children, ages five days to six years, and 11 adults, ages forty-two to seventy-nine years. All the children had either a neurogenic dysphagia or an esophageal lesion. We found no cases of aspiration of barium sulfate during examination of normal infants. Our observations confirm DeCarlo and co-workers'[10] report that the normal newborn may aspirate the oily opaque medium but as a rule does not aspirate a barium sulfate-water mixture.

The amount aspirated varied from a trace of the material in the trachea and

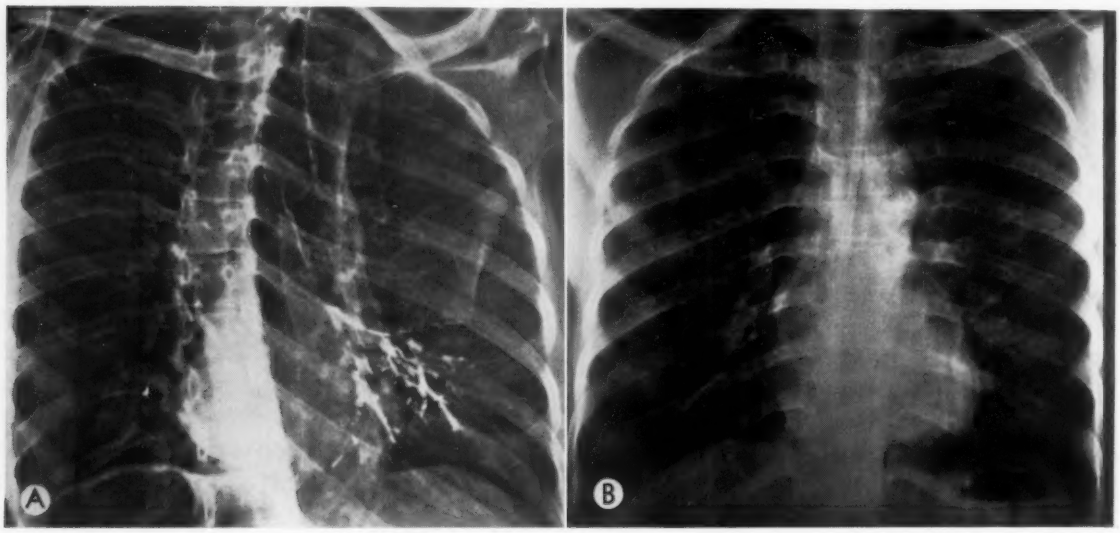

FIG. 1. Case XVI. (*A*) Aspiration of thin barium sulfate-water mixture during barium swallow examination. Diagnosis: Carcinoma of the nasopharynx. There was no immediate or delayed reaction. (*B*) One day after aspiration of barium sulfate. No residual barium sulfate is evident and the lungs are clear.

main bronchi in 7 cases to a quantity sufficient to produce a bronchogram of one or more lobes in 9 cases. Usually the bronchogram was confined to the major bronchial segments (Fig. 1*A*). In only one case (Case VI) did alveolar filling occur. Follow-up chest roentgenograms revealed that the barium sulfate was rapidly eliminated from the lungs. In most cases the lungs were clear by the next day (Fig. 1*B*). In the one case that showed alveolar filling, the barium sulfate in the bronchi disappeared in one day and the peripherally distributed barium sulfate gradually cleared over a period of several weeks. Later chest roentgenograms in 3 cases, after seven months, one year, and two years respectively, showed no evidence of reaction or residual changes in the lungs.

In all but one case there was no immediate or delayed reaction to the aspiration of the barium sulfate. One patient (Case XI) developed elevation of temperature a few hours after aspiration of vomited barium sulfate mixed with stomach contents (Fig. 2*A*). Two days later the temperature was normal, and a chest roentgenogram at this time showed no residual barium sulfate in the lungs. Death occurred two weeks later from carcinomatosis. Autopsy showed aspiration pneumonia bilaterally with no difference in appearance between the areas where barium sulfate had previously been seen and other areas where no barium sulfate had been seen. Examination of the lung specimen did not show any barium sulfate in the lungs. A roentgenographic examination of the removed lung specimen did show, however, emphysematous cysts present only in the left lower lobe, the only lobe that received the aspirated barium sulfate (Fig. 2*B*). Autopsy in 3 other cases showed nonspecific aspiration pneumonia in 2 cases and normal lungs in one case. None showed evidence of residual barium sulfate. All cases are summarized in Table 1.

EXPERIMENTAL STUDY

MATERIAL AND METHOD

Twenty dogs, all puppies less than one year old, varying in weight from 1.5 to 8.3 kg., were used. The animals were anesthetized with intravenous sodium pentobarbital; then an intratracheal catheter was passed under direct vision. After positioning the tip of the catheter fluoroscopically, a measured amount of barium sulfate-water mixture was injected. Three parts barium sulfate to five parts water were used to approximate the consistency of the mixture used in routine gastrointestinal studies.

TABLE I

SUMMARY OF CASES OF ASPIRATION OF BARIUM SULFATE

Case No.	Age and Sex	Diagnosis	Amount of $BaSO_4$ Aspirated	Immediate Reaction	Follow-up Chest Roentgenogram	Clinical Course	Autopsy Findings
I	5 da. M.	Tracheoesophageal fistula	Bronchogram of left lung	None	1 wk.—chest clear; 1 yr.—chest clear	Operative correction of fistula uneventful. Alive and well at 1 yr.	—
II	2 yr. M.	Brain tumor	Partial bronchogram bilaterally	None	None	No pulmonary sequelae. Died 1 yr. later	Lungs—bilateral aspiration pneumonia. No evidence of barium sulfate
III	2 yr. F.	Hydrocephalus	Outline of trachea	None	1 da.—chest clear; 7 mo.—chest clear	No pulmonary sequelae. Died 7 mo. later	Lungs—normal
IV	2 yr. F.	Diverticulum of esophagus	Partial bronchogram of both lower lobes	None	2 da.—no residual barium sulfate. Pneumonia of right upper lobe unchanged from roentgenograms prior to aspiration of barium sulfate. 5 wk.—lungs clear	Diverticulum resected 3 da. later. Postoperative course febrile with bilateral pneumonia for 3 wk. Discharged well at five weeks	—
V	6 yr. M.	Esophageal stricture (lye burn)	Outline of trachea	None	1 wk.—chest clear; 4 mo.—chest clear	Uneventful surgical repair of esophagus. No pulmonary sequelae. Well 4 mo. later	—
VI	60 yr. M.	Carcinoma of esophagus	Complete bronchogram of left lung	None	1 da.—traces of barium sulfate remaining. Gradual clearing in several weeks. 1 yr.—lungs clear	No pulmonary sequelae. Died 1 yr. later	Not obtained
VII	65 yr. M.	Carcinoma of esophagus	Outline of trachea	None	1 da.—chest clear	Not available	—
VIII	42 yr. F.	Pulsion diverticulum of esophagus	Outline of trachea	None	Not available	Not available	—
IX	62 yr. M.	Carcinoma of esophagus	Bronchogram of left lower lobe	None	Not available	No pulmonary sequelae. Patient discharged from hospital 2 wk. later. No subsequent follow-up	—
X	63 yr. F.	Carcinoma of thyroid	Outline of trachea	None	9 mo.—lungs clear	No pulmonary sequelae. Alive 9 mo. later	—
XI	70 yr. M.	Carcinoma of stomach	Bronchogram of left lower lobe	Yes	1 da.—pneumonia of left lower lobe, traces of barium sulfate. 2 da.—left lower lobe clearing. No barium sulfate visible	Patient aspirated vomitus of barium sulfate and stomach contents. 4 hr. later—temp. 102°F.; 2 da. later—temp. normal; 2 wk. later—patient died	Lungs—metastatic tumor and aspiration pneumonia in both lower lobes. Roentgenogram of removed lungs showed emphysematous cysts in left lower lobe only. No evidence of residual barium sulfate
XII	45 yr. M.	Carcinoma of esophagus	Partial bronchogram of scattered branches bilaterally	None	Not obtained	5 mo. later—patient died from carcinomatosis	Lungs—bilateral aspiration pneumonia. No barium sulfate seen histologically
XIII	55 yr. M.	Tracheal adenoma	Outline of trachea and both major bronchi	None	2 yr.—lungs clear	2 yr. after first admission tumor recurred. No pulmonary sequelae from aspiration of barium sulfate	—
XIV	52 yr. F.	Pulsion diverticulum of esophagus	Outline of trachea and main bronchi	None	5 da.—lungs clear	Not available	—
XV	63 yr. F.	Carcinoma of esophagus	Partial bronchogram of left lung	None	1 da.—traces of barium sulfate; 1 wk.—no barium sulfate visible	2 wk. later developed pneumonia in right base. Left lung remained clear during next 3 mo. No further follow-up	—
XVI	47 yr. F.	Carcinoma of nasopharynx	Bronchogram of right middle lobe and right lower lobe	None	1 da.—lungs clear. No residual barium sulfate	No pulmonary sequelae. 2 yr. later—died from carcinomatosis	Not obtained

Amounts of 1, 3, 5, 8, and 10 cc. were injected. In 15 animals, the injection was made with the tip of the catheter in one of the main bronchi and in the other 5 the injection was made into the trachea above the carina. The first 8 dogs received an unsterile mixture of barium sulfate and tap water. The other 12 received a mixture sterilized by boiling. No detectable differences occurred in the two groups. Chest roentgenograms were obtained immediately before and after injection of the bari-

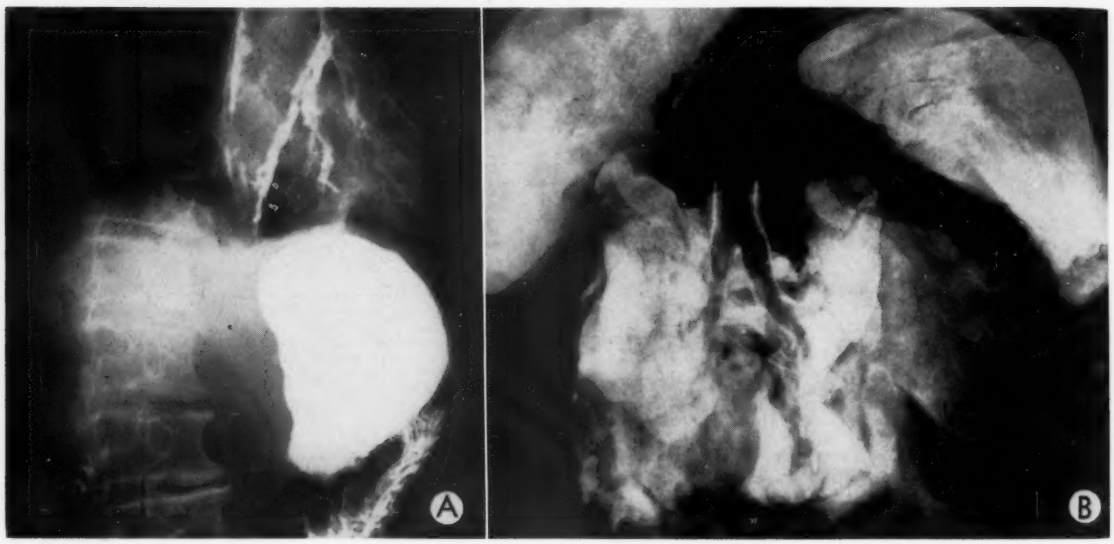

FIG. 2. Case XI. (*A*) Aspiration of vomited barium sulfate into left lower lobe during a gastrointestinal series. Diagnosis: Inoperable carcinoma of the stomach. No barium was visible on the right side. A few hours later the patient developed elevation of temperature and signs of pneumonia at the left base. Two days later the lungs were clear with no evidence of residual barium sulfate. This is the only patient in the series who manifested a reaction after aspiration of barium sulfate. Two weeks later death occurred from carcinomatosis. (*B*) Postmortem roentgenogram of lungs of same case. No residual barium sulfate is evident. Histologically the left lower lobe showed aspiration pneumonia that was no different from changes present in all other lobes. Note, however, the emphysematous cysts present only in the areas into which the barium sulfate was aspirated.

um sulfate and every two or three days thereafter, the last one being immediately before the animal was autopsied.

At intervals of 1, 2, 24 and 48 hours and 12, 14, 17 and 168 days, the animals were sacrificed by large doses of intravenous pentobarbital and autopsied immediately thereafter. The trachea was clamped before opening the chest to minimize postmortem deflation of the lungs. A roentgenogram of the removed lungs was obtained, then sections for histologic study were taken from each lobe. In the first 12 cases, roentgenograms were made of the removed liver and spleen. Histologic studies of these organs were not done as no barium was detected in them.

RESULTS

Two dogs died. One animal failed to recover from the anesthesia, dying nineteen hours afterward without regaining consciousness. Autopsy showed pneumonia in the right middle lobe and both lower lobes with barium sulfate distributed throughout the bronchi of these lobes. Another animal contracted distemper during an epidemic that also affected a number of other dogs not in this series housed in nearby cages. This dog was well for eleven days after instillation of the barium sulfate. On the twelfth day he became ill, and on the fourteenth day he died with evidence of pneumonia bilaterally.

The other 18 dogs recovered from the anesthesia and remained clinically well until the time of autopsy. The temperature and white blood cell count of the first 8 dogs were determined daily from the time of instillation of the barium sulfate for one week, or until autopsy for those animals sacrificed at shorter intervals. These determinations remained normal for all the animals.

ROENTGENOGRAPHIC FINDINGS

Immediately following instillation of the barium sulfate, the distribution of the barium in the bronchi appeared similar to bronchograms done with other opaque media. There was dense opacification of the secondary and tertiary bronchi, with some

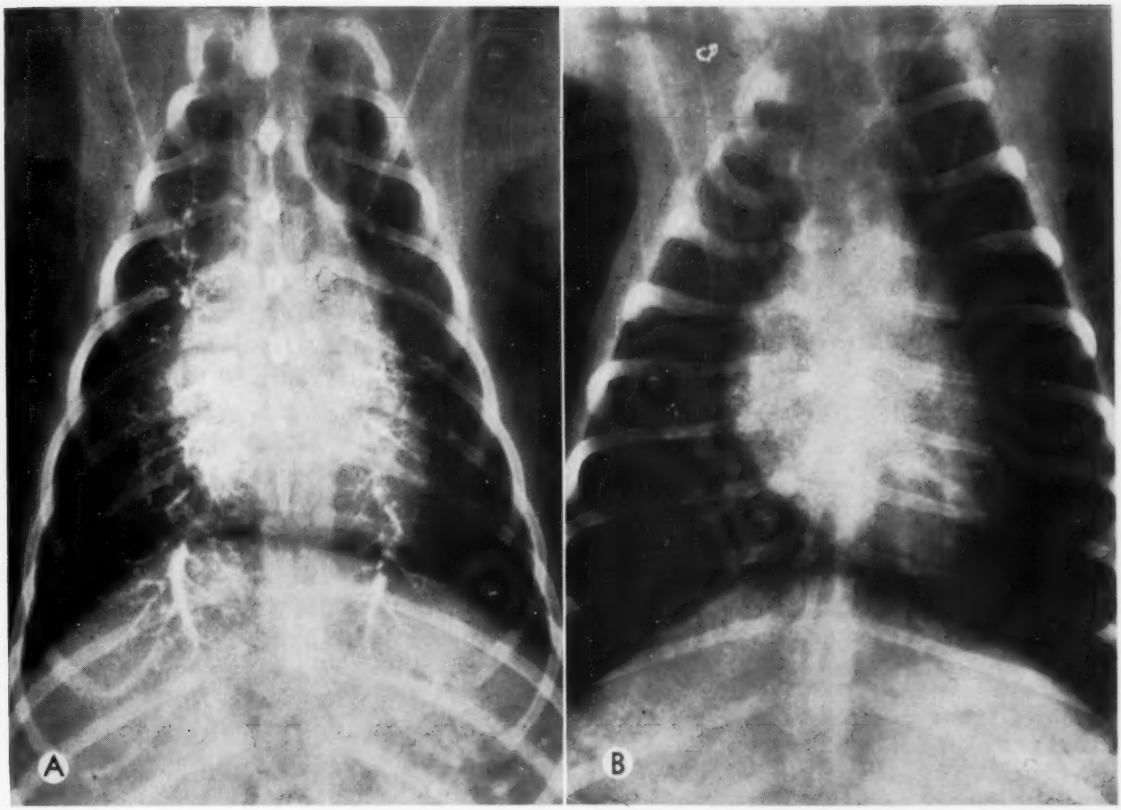

Fig. 3. Dog No. 8. (*A*) Bronchogram immediately after instillation of 5 cc. of barium sulfate-water mixture. (*B*) Eleven days later. Note the presence of peripherally dispersed barium sulfate. The bronchi were cleared of barium sulfate in about twenty-four hours. Essentially no change occurred in the chest roentgenograms from the third to the seventeenth days, when the animal was sacrificed. Similar observations were noted in another animal followed for 168 days.

tendency to more peripheral filling. Subsequent roentgenograms showed progressive clearing of the larger bronchi and more peripheral dispersal of the retained material (Fig. 3). After a few days, there was essentially no change in the appearance of the peripherally dispersed material.

PATHOLOGIC OBSERVATIONS

Gross Morphology. In general, the lungs at autopsy were pink, light and well aerated, showing no gross abnormalities. In a few specimens, firmer and darker areas were found which represented postmortem deflation. No grossly visible emphysema was observed. In one animal, however, there was a noticeable difference in the degree of postmortem deflation of the two lungs. The right lung, which contained the barium sulfate, remained more inflated than the left, which contained no barium sulfate (Fig. 4).

Animals sacrificed in the first few days showed variable amounts of white or yellow material in the bronchi which appeared to be a mixture of barium sulfate and mucous or mucopurulent secretion. In animals sacrificed at later intervals, the bronchi were clear and the mucosal linings appeared normal.

Roentgenograms of the removed lungs showed a pattern corresponding to that seen in the antemortem roentgenograms. In animals sacrificed within the first few hours, there was a clearly etched bronchogram of the major and minor bronchi (Fig. 5). In animals sacrificed at later stages, there was a disseminated granular peripheral distribution without profile of the bronchial tree (Fig. 6). In some specimens, the postmortem roentgenograms revealed

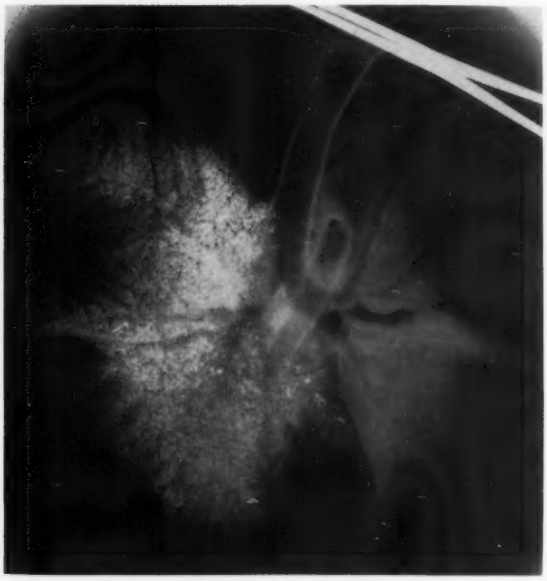

FIG. 4. Dog No. 15. Removed lungs of dog sacrificed two hours after instillation of 8 cc. barium sulfate-water into the right main bronchus. The trachea was not clamped before opening the thorax. Note the inflated state of the barium-filled lung as compared to the collapsed opposite lung.

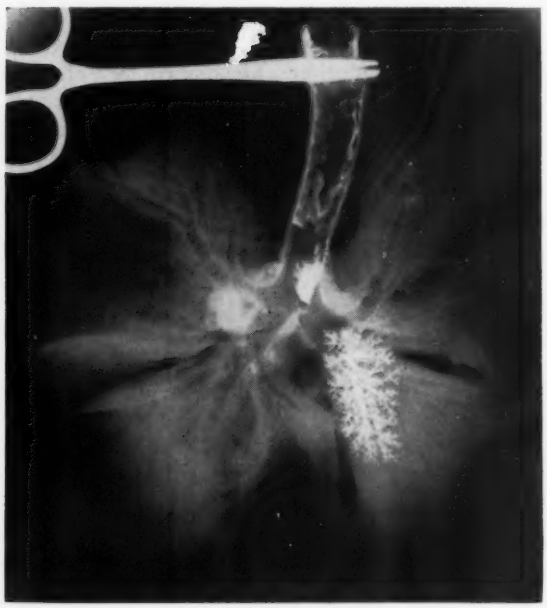

FIG. 5. Dog No. 14. Removed lungs of dog sacrificed one and one-half hours after instillation of 3 cc. barium sulfate-water. Tip of catheter was in the left lower lobe bronchus. The barium in the trachea represents material that was coughed up. The clearly etched bronchogram is typical of the appearance in animals sacrificed in the first few hours after injection. Compare with the later appearance (Fig. 6).

small amounts of finely dispersed barium sulfate that were not demonstrable on the antemortem roentgenograms.

To study the efficiency of the respiratory tract in clearing itself of the barium sulfate, a comparison was made between the postmortem roentgenograms of the group of 5 dogs in which the barium was deposited in the trachea above the carina and the group of 15 dogs in which the barium was deposited below the carina (Table II). In the first group, which received the barium sulfate above the carina, 3 of the 5 dogs showed no retained barium sulfate and one showed a few tiny flecks scattered throughout both lungs. The other animal, which died without recovering from the anesthesia, retained all of his dose in the lower lobes. In the second group, which received the barium sulfate below the carina, 13 of the 15 animals retained appreciable amounts of the barium in the lungs. The other 2 animals showed no residual barium. Although the number of animals is small, the clear-cut difference in the two groups

FIG. 6. Dog No. 6. Removed lungs of dog sacrificed two days after instillation of 5 cc. barium sulfate-water mixture showing disseminated granular peripheral distribution of the barium sulfate. In other animals followed for longer periods, serial chest roentgenograms showed little change in this pattern after the first few days.

Table II

RELATION OF BARIUM SULFATE RETENTION TO LEVEL OF THE INSTILLATION

	No. of Dogs	Residual $BaSO_4$ in Lungs
Dose Proximal to the Carina	5	2*
Dose Distal to the Carina	15†	13

* One dog received 8 cc. and retained only a few minute scattered traces of barium sulfate. The second dog in this group never recovered from anesthesia and retained all of his 3 cc. dose.

† Two dogs, receiving 1 cc. and 8 cc. doses respectively, successfully cleared every trace of barium sulfate from the respiratory tract despite instillation below the carina.

would appear to indicate that the upper respiratory tract of a healthy dog is quite efficient in ridding itself of aspirated material, while the lower respiratory tract is less efficient in this regard. From these observations, one might reasonably assume that if a patient aspirated barium into the trachea, it would probably be coughed up with little or no retention in the lungs. This assumption is supported by the findings in the series of patients studied.

Histologic Findings. The histologic findings confirmed the impression from the roentgenograms that initially the barium sulfate was confined to the lumen of the segmental and subsidiary bronchi and later appeared more peripherally, even out to the alveoli. In the bronchi, the barium was distributed in three stages of aggregation: (a) solid casts filling the lumen, (b) small clumps, and (c) loose granular material (Fig. 7).

Generally, casts were found in bronchioles or smaller subdivisions. Clumps were found in both large and small subdivisions of the bronchial tree. Granular material showed a tendency to be either cleared from the respiratory tract or aspirated into the alveoli. Many of the lobes containing barium sulfate also contained small foci of atelectasis or emphysema. In some lobes, the change was predominantly atelectasis; in others, emphysema. In still a third pattern, atelectasis was interspersed with emphysema. The latter change was noted particularly in areas of peripherally disseminated barium sulfate in which alveolar ducts were coated.

A correlation of the form of the barium present in the lungs and the presence of emphysema or atelectasis suggested that these changes were mechanical in origin, the result of plugging of the bronchi by the barium sulfate. To assess this factor, each of the lobes from each dog was evaluated separately for (1) the presence of barium in the form of (a) clumps or casts and (b) granules, and (2) the presence of significant degrees of emphysema or atelectasis. Of the lobes containing clumps or casts, 92 per cent showed atelectasis or emphysema. Of the lobes containing granules only, none showed atelectasis or emphysema and of those containing no barium, 16.7 per cent showed these changes. These results are summarized in Table III and are illustrated in Figure 7.

It should be stressed that the mechanical effects observed were minimal in degree and essentially microscopic in extent, with the one exception previously mentioned (Fig. 4).

Tissue Reaction. The detailed histologic findings are being reported elsewhere. The tissue response consisted of a mild transient acute and subacute bronchial and peribronchial inflammatory reaction which was quickly replaced by a bland foreign body reaction (Fig. 8). The latter was quite active in the early stages, but at three weeks had a relatively indolent appearance without evidence of fibrosis. Granular barium appeared to be readily phagocytized and mobilized. On the other hand, aggregated material formed large hyaline masses

Table III

MECHANICAL EFFECT OF BARIUM SULFATE IN LUNGS

Barium Sulfate in Lungs	Total No. of Lobes	Atelectasis or Emphysema	Per Cent
No Retained Barium	24	4	16.7
Granules Only	6	0	0
Clumps or Casts	13	12	92.3

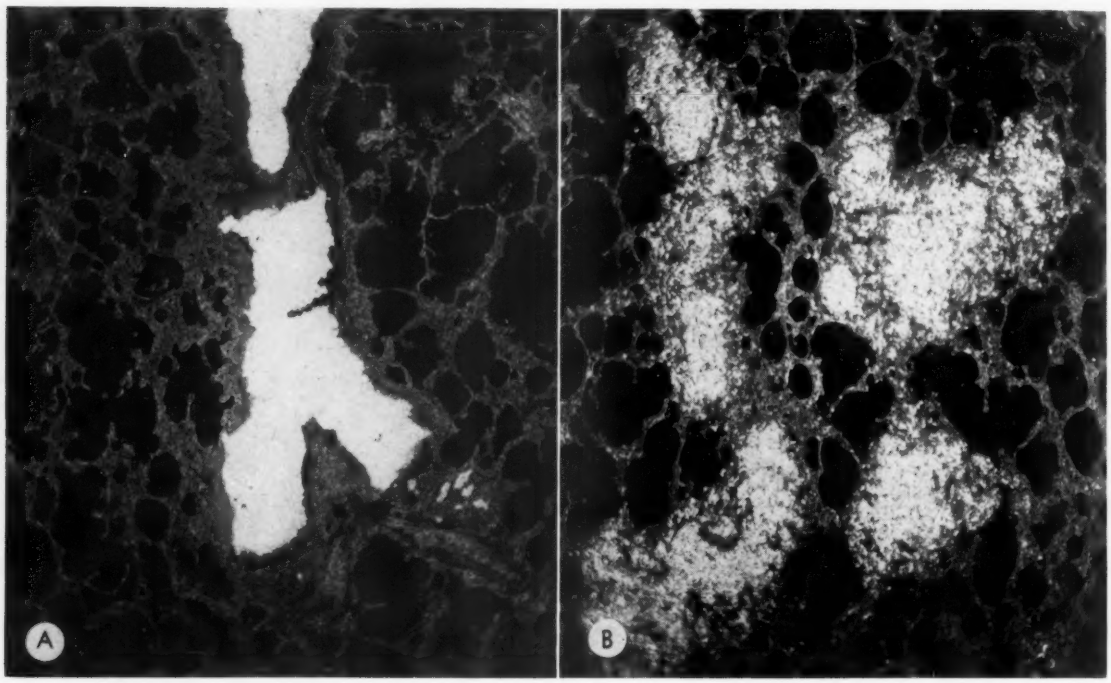

FIG. 7. Microscopic appearance of barium sulfate in the lungs. (*A*) Casts of small bronchi and bronchioles. (*B*) Clumps in respiratory bronchioles and alveoli. Note the microscopic emphysema and atelectasis. (Dark field illumination. Barium sulfate appears white. Air spaces are black.)

into which phagocytes seemed to penetrate with difficulty. These masses tended to remain immobile and formed large granuloma-like nodules.

CONCLUSIONS

Both the clinical and experimental observations of this study indicate that barium sulfate acts in the lungs as a relatively inert foreign body. There was no evidence of a toxic reaction in either the group of patients studied or in the experimental animals. Histologic examinations in the animal experiment showed only a mild foreign body reaction to the barium sulfate and no evidence of fibrosis. Both the clinical and experimental investigations showed that the respiratory tract is very efficient in removing barium sulfate from the bronchi.

The experimental investigation did show that it is possible for barium sulfate to produce foci of atelectasis or emphysema by mechanically plugging the bronchi. This possibility is suggested also by the one case in the clinical series that showed evidence of emphysematous cysts only in areas where barium sulfate previously had been aspirated. It should be emphasized, however, that these changes, as observed under the conditions of this experiment, were spotty in fashion affecting only a small fraction of the total lung volume.

From a practical standpoint, it would appear from this study that when aspiration of barium sulfate occurs, no reaction need be anticipated and no specific therapy is indicated. Regarding bronchography with barium sulfate, it would appear that there is no contraindication to this procedure, except that possibly instillation of a large amount of barium sulfate into a small volume of lung may be undesirable. Further study of the mechanical effects of barium sulfate is necessary before any definite conclusions can be drawn.

SUMMARY

Sixteen cases of aspiration of barium sulfate were reviewed. None showed any signs of acute or chronic toxic effects attributable to the barium sulfate.

The effects of barium sulfate on the lungs

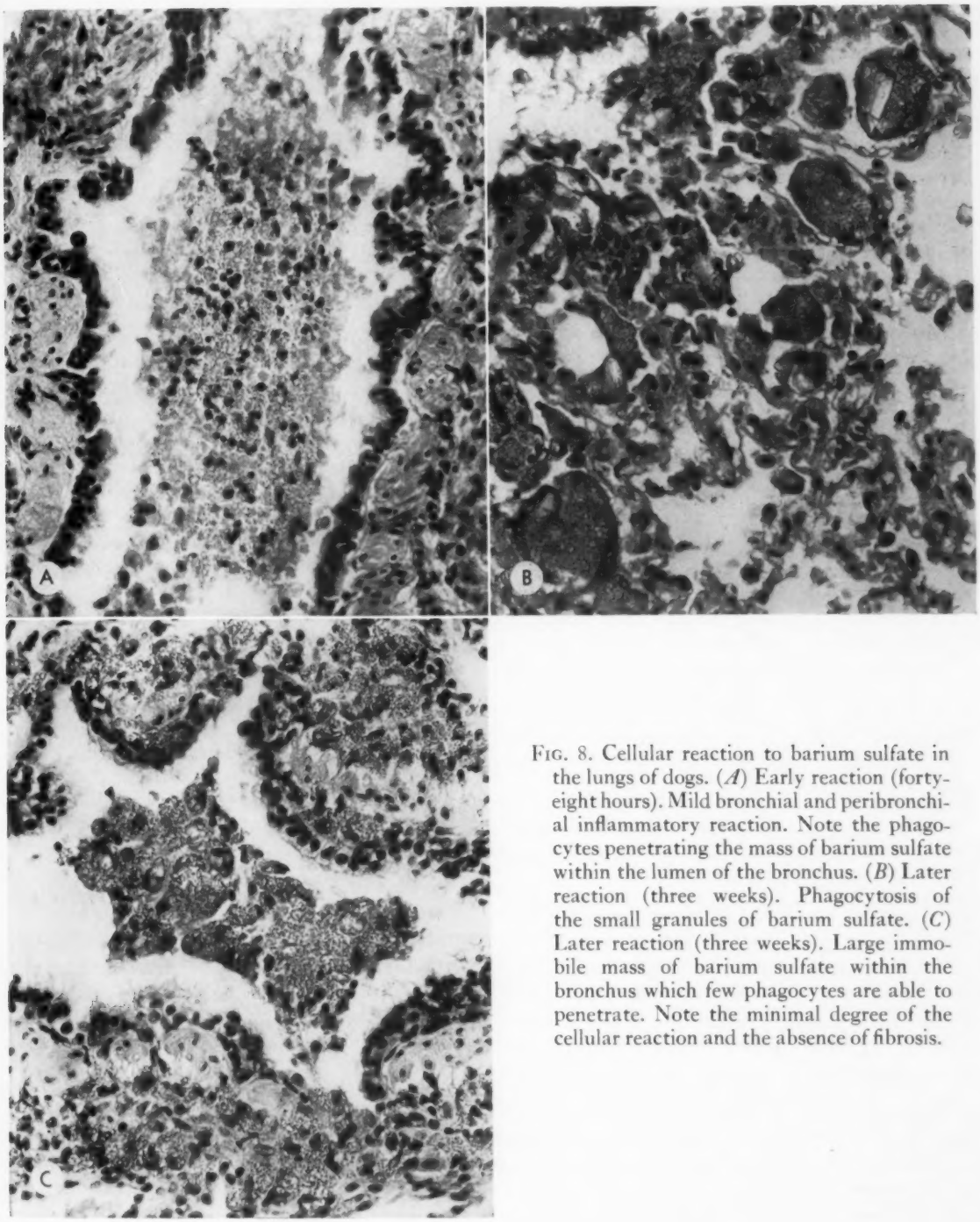

FIG. 8. Cellular reaction to barium sulfate in the lungs of dogs. (*A*) Early reaction (forty-eight hours). Mild bronchial and peribronchial inflammatory reaction. Note the phagocytes penetrating the mass of barium sulfate within the lumen of the bronchus. (*B*) Later reaction (three weeks). Phagocytosis of the small granules of barium sulfate. (*C*) Later reaction (three weeks). Large immobile mass of barium sulfate within the bronchus which few phagocytes are able to penetrate. Note the minimal degree of the cellular reaction and the absence of fibrosis.

were studied experimentally by intratracheal instillation of barium sulfate in 20 dogs. Clinically, the dogs manifested no ill effects. Pathologically, it was observed that when sufficient barium sulfate remained in the bronchioles to become inspissated, focal atelectasis and emphysema resulted. The affected portions of the lungs were limited in extent. Histologically, the retained barium sulfate stimulated only a bland foreign body reaction.

These findings, together with a review of the clinical and experimental literature, appear to justify the conclusions that the as-

piration of barium sulfate is usually of no consequence, and that under certain conditions barium sulfate may be a useful bronchographic medium.

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REFERENCES

1. ADOLPH, W., and TAPLIN, G. V. Use of micropulverized barium sulfate in x-ray diagnosis; a preliminary report. *Radiology*, 1950, *54*, 878–883.
2. ANÉ, J. N., and MENVILLE, L. J. Various radiopaque substances and their toxicity when used to visualize reticulo-endothelial system of laboratory animals. AM. J. ROENTGENOL. & RAD. THERAPY, 1932, *28*, 784–786.
3. ARRIGONI, A. Pneumoconiosi da bario. *Clin. med. ital.*, 1933, *64*, 299–324.
4. ARRIGONI, A. Pneumoconiosi da bario. (Osservazioni clinico-radiologiche e-sperimentali.) *Med. lavoro*, 1933, *24*, 461–468.
5. BEDDOE, H. L., KAY, S., and KAYE, S. Barium granuloma of rectum; report of case. *J.A.M.A.*, 1954, *154*, 747–749.
6. CAMBA, R. Contributo alla conoscenza dell' azione delle polveri di barite sull'uomo. *Med. lavoro*, 1951, *42*, 221–226.
7. CEMBER, H., HATCH, T. F., WATSON, J. A., and GRUCCI, T. B. Pulmonary effects from radioactive barium sulfate dust. *A.M.A. Arch. Indust. Hyg.*, 1955, *12*, 628–634.
8. CEMBER, H., HATCH, T. F., WATSON, J. A., and GRUCCI, T. B. Pulmonary penetration of particles administered by intratracheal insufflation. *A.M.A. Arch. Indust. Hyg.*, 1954, *10*, 124–129.
9. DAVIS, L. A., HUANG, KEE-CHANG, and PIRKEY, E. L. Water-soluble, non-absorbable radiopaque mediums in gastrointestinal examination. *J.A.M.A.*, 1956, *160*, 373–375.
10. deCARLO, J., JR., TRAMER, A., and STARTZMAN, H. H., JR. Iodized oil aspiration in newborn. *A.M.A. Am. J. Dis. Child.*, 1952, *84*, 442–445.
11. DiRIENZO, S., and DUARTE, R. O. P. Die Bronchographie mit Barium. *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, 1957, *86*, 315–318.
12. Editorial. Poisoning by barium salts. AM. J. ROENTGENOL., 1916, *3*, 334–335.
13. ELLIOTT, J. S., and ROSENBERG, M. T. Ureteral occlusion by barium granuloma. *J. Urol.*, 1954, *71*, 692–694.
14. FECI, L. Pneumoconiosi nei lavoratori di barite. (Nota preventiva.) *Radiol. med.*, 1933, *20*, 620–624.
15. FISHEL, C. R. Inhalation of barium in solution. *J.A.M.A.*, 1923, *80*, 102.
16. HUSTON, J., JR., WALLACH, D. P., and CUNNINGHAM, G. J. Pulmonary reaction to barium sulfate in rats. *A.M.A. Arch Path.*, 1952, *54*, 430–438.
17. ISAACS, I. Intraperitoneal escape of barium enema fluid perforation of sigmoid colon. *J.A.M.A.*, 1952, *150*, 645–646.
18. KLEINSASSER, L. J., and WARSHAW, H. Perforation of sigmoid colon during barium enema; report of case with review of literature, and experimental study of effect of barium sulfate injected intraperitoneally. *Ann. Surg.*, 1952, *135*, 560–565.
19. KRISAN, Z. *et al.* Experimental bronchography with aqueous dispersed solution of barium sulfate. *Bratisl. lek. listy*, 1955, *35*, 280–283.
20. MASSHOFF, W. Fremdkörpergranulome des Peritoneums durch Röntgenkontrastbrei. *Arch. f. klin. Chir.*, 1938, *194*, 165–170.
21. McNALLY, W. D. Two deaths from administration of barium salts. *J.A.M.A.*, 1925, *84*, 1805–1807.
22. PENDERGRASS, E. P., and GREENING, R. R. Baritosis; report of case. *A.M.A. Arch. Indust. Hyg.*, 1953, *7*, 44–48.
23. POTTS, W. J. Intestinal obstruction in newborn. *Seminar Report*, 1956, *1*, 8–17.
24. SARI, A. *et al.* Bronchographie mit der wasserigen dispersen Baryum sulfat-Lösung. *Ceskoslov. Onkologia*, 1956, *3*, 83–86.
25. SULLIVAN, S. J. Aspiration of barium facilitating death in debilitated patient. *J.A.M.A.*, 1934, *103*, 337–338.
26. SWARTZ, L. W. Barium granuloma of rectum following barium enema; case report. *Am. J. Surg.*, 1955, *90*, 802–804.
27. WURZ, P. Poisoning with barium preparations in roentgen ray studies. *Deutsche Ztschr. Gerichtl. Med.*, 1924, *5*, 173–187.

THE ROENTGENOLOGIC EVALUATION OF SYSTEMIC LUPUS ERYTHEMATOSUS*

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THE roentgenologic changes occurring in systemic lupus erythematosus have been the subject of discussion in other articles.[11,32] Changes occurring in chest roentgenograms of patients seen at the Philadelphia General Hospital prior to 1951 were previously reported by Israel.[14] More recently, we have evolved a system for pathologically correlating postmortem material with roentgenograms of the disease. This has taught us the importance of proper interpretation of chest roentgenograms and the value of using history to aid us in making this difficult diagnosis. A history of joint pain and the pericardial, perivascular, interstitial, and pleural inflammatory changes which are visible in chest roentgenograms provide evidence which is almost pathognomonic of acute systemic lupus erythematosus. In resolving and chronic stages there are likewise changes which show a similarity in appearance, when roentgenograms taken from clinically comparable stages of the disease are studied. It is the purpose of this article to discuss these changes and to show how in some instances roentgenologic criteria can be used to establish the diagnosis of systemic lupus erythematosus.

ETIOLOGY

The exact etiology of systemic lupus erythematosus (SLE) is still unknown. However, the recent discovery of a pathologically similar syndrome caused by prolonged, intensive hydralazine therapy introduces strong evidence that this disease may be some type of a poorly understood allergic reaction.[7,23]

In some instances it is believed that discoid lupus erythematosus precedes the systemic form.[17,28] In other instances the systemic form is not associated with skin rash, or the rash occurs after the onset of systemic symptoms. One can conclude that discoid and systemic forms of lupus erythematosus are very closely related and could possibly be different stages of the same disease.

Heredity has been implicated as a factor in the etiology but not proved.[10] It seems to be well established that systemic lupus erythematosus is more common in young and middle aged adult women, and this sex and age relationship is apparent in our series.[12]

CLINICAL SYNDROME[12,13]

The acute syndrome of systemic lupus erythematosus usually presents as a variable combination of pleuritis, pneumonitis, and migrating polyarthritis associated with malaise, weight loss, and fever unresponsive to antibiotics. Occasionally, mental and neurologic defects will be the first complaint. Often, some evidence of the nephrotic syndrome will be apparent. The pulse is rapid due to hyperthermia, and nonspecific heart murmurs may occur. Petechiae are often seen, and erythema nodosum is occasionally present. The facial butterfly rash varies, and a similar rash may occur on other exposed body surfaces. The exacerbations of articular swelling and pain are similar to those observed in rheumatoid arthritis and are frequently confused.

Following cortisone therapy a remission usually occurs, but permanent renal changes may produce a nephrotic syndrome. The remissions may or may not be

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lasting, and patients are very susceptible to pulmonary infections during all stages of the disease.

LABORATORY STUDIES

The most important laboratory findings are: positive LE test, albuminuria, reversed A–G ratio, and electrocardiographic evidence of pericarditis and nonspecific myocarditis. Low normal leukocyte counts are present unless secondary infection occurs.

The LE test is unusually specific;[12,13] however, it may be negative in early stages or during a remission. There is a difference of opinion regarding false positive results except in the case of hydralazine toxicity.[12]

PATHOLOGY

The primary pathologic changes are caused by involvement of the capillaries, arterioles, and venules by a diffuse endothelial inflammation. This inflammation produces necrosis of the vessel walls. In addition, the interfibrillary ground substance is altered; and straightening and thickening of the connective tissue fibers occur. This latter change has been called "fibrinoid degeneration" by Klemperer *et al.*[16] Later, endothelial proliferation follows, which apparently represents a response to the acute vascular inflammation. Hematoxylin bodies appear in the viscera and probably represent collections of abnormal proteins.[4,15]

In the kidneys, fibrinoid degeneration results in a typical "wire loop" thickening of the basement membrane of the glomerular tufts.[3,16,30] In the spleen, an "onion skin" periarteriolar fibrosis develops.[16]

Perivascular inflammation and fibrinoid degeneration affect all of the cardiac structures.[2,16] The endocardium is often the site of a verrucous endocarditis which involves the mural endocardium as well as the valvular endocardium (Libman-Sacks endocarditis).[19] The myocardium is diffusely injured, and myocardial failure and cardiac dilatation may result.[11] The epicardium microscopically shows inflammation and fibrinoid degeneration which extend into the visceral pericardium. This results in a fibrinous pericarditis which is rough to the touch and presents a dull appearance. In later stages adhesions are often present between visceral and parietal pericardium and more frequently involve the pericardial sac around the base of the heart.[24] Pericardial fluid may accompany the adhesions, the amount being limited by the number of adhesions. In the nephrotic syndrome the fluid increases and may be massive in the acute stages. The amount of pericardial effusion found at postmortem examination is usually small to minimal and is easily overlooked. When minimal, the effusion may have a high protein content and be yellow, viscous, and turbid in appearance.

The pleural changes in the acute stage consist of fibrinous inflammation and focal areas of necrosis. The early changes are followed by varying degrees of pleural fibrosis; and multiple thin pleural adhesions, similar to the pericardial adhesions, may occasionally limit the amount of effusion or cause loculation of the effusion. The amount of associated pleural effusion may be moderately severe and serous in the acute stage or minimal and viscous in the chronic stage. The effusion is rarely massive except in the initial acute stage.

The pathologic changes in the lungs have been described by Rakov and Taylor,[27] Foldes,[8] Teilum,[31] Baggenstoss,[2] Purnell *et al.*,[25] Aitchison and Williams,[1] and Harvey *et al.*[12] Kuzma[18] has summarized the findings of these authors and co-ordinated the pathologic changes of all collagen diseases. According to his theory, the pulmonary changes of the collagen diseases are pathologically related and vary only in degree and rapidity of onset. Both acute and chronic changes occur and are found co-existing in the lungs unless the patient dies early during the initial acute episode or during a remission from secondary causes. The following is a summary of the important findings described by the various authors: The first pulmonary changes observed are due to the precipitation of acid

mucopolysaccharides. This occurs primarily within the alveolar walls and within interstitial supporting structures ("mucinous edema" as described by Baggenstoss[2]). Segments of the alveolar walls show widening and increased cellularity. Intra-alveolar extravasation of protein ("hyaline membranes") and erythrocytes are seen in these segments. Minute to massive multiple hemorrhages appear in the lungs and are related to necrosis of the walls of the smaller blood vessels. Thrombi within the smaller pulmonary blood vessels are also found. During this initial stage the gross appearance of the lung is that of a combination of two pathologic processes: mottled foci of hemorrhage and small, focal interstitial areas of consolidation. Shortly thereafter, inflammatory cells make their appearance; and a process of organization and repair of the areas of interstitial mucinous edema begins. Organization of the exudate within the alveolar spaces also occurs, and the alveolar lining cells undergo extensive proliferation. Later, there is a condensation of the ground substance of the involved areas (fibrinoid necrosis) which is most often recognized where it surrounds and constricts the blood vessels. The inflammatory exudate disappears, fibroblasts multiply, and the alveolar walls become thickened. In the final, chronic stage, breakdown of the alveolar septa occurs with formation of small cystic spaces in the lungs.

In the joints the pathologic changes are usually limited to fibrinoid degeneration and perivascular inflammation. Not seen are the other changes of rheumatoid arthritis, such as adhesions across the joint clefts and pannus at the perichondral margins of the cartilage surfaces. The number of pathologically studied cases, however, is limited.[5,20]

ROENTGEN CHANGES

Until very recently, the roentgen changes in systemic lupus erythematosus have been considered to be nonspecific.[21] Within the last decade Thorell[32] has described several cases with roentgen changes of the lungs and has pathologically correlated these changes with the work of Teilum.[31] In particular, Thorell noted focal subpleural areas of pneumonitis and atelectasis which were associated with pleural thickening.

Gould and Daves[11] analyzed 100 cases of systemic lupus erythematosus with roentgen findings, and they also noted horizontal basilar plaques and/or patches of pneumonitis in about 50 per cent of the cases. Pleuritis and/or effusion were present in 74 per cent of the cases, occurring bilaterally in 51 per cent. The pleuritis and effusion were basilar and frequently did not show a meniscus sign. Varying enlargement of the cardiac silhouettes was demonstrated in 53 per cent of the series; and because of frequent cardiac dilatation found at autopsy, Gould and Daves suggested that the marked variation in cardiac silhouette could best be explained by myocarditis. Only one of their cases had osseous changes of the joints similar to rheumatoid arthritis. They concluded that the diagnosis of systemic lupus erythematosus could be suspected in many cases by the marked variation in the cardiac silhouette, minimal bilateral pleuritis or effusion, horizontal plaques and patches of pneumonitis at the lung bases, slight splenic enlargement, and lack of joint destruction.

METHOD OF INTERPRETATION

A review of all chest roentgenograms taken in 23 proved cases of systemic lupus erythematosus in our series demonstrated definite roentgen findings which reflected acute or chronic inflammatory changes in the pleura, lungs, and pericardium. Our method of roentgenologic interpretation is described below and depended upon commonly accepted criteria and personal experience obtained from correlation of the roentgenograms with the gross pathologic specimens.

Pericardial Effusion. In pericardial effusion, straightening of the left border of the cardiac silhouette is observed in the segment of the pulmonary vessels. This appearance is caused by pericardial fluid

which surrounds the pulmonary conus and main pulmonary artery. With small or moderate effusion, the main pulmonary artery appears as a shallow convexity at the left heart border in this area, but in larger effusions the shadow of the pulmonary artery is completely lost. Because the pericardium is continuous and surrounds the heart and great vessels, the lower border of the aortic knob is also hidden by the minimal effusion. This straightening of the left border of the cardiac silhouette due to minimal pericardial effusion is illustrated in Figure 2. Autopsy in this case clearly demonstrated that the straightening of the pulmonary segment of the heart shadow was the result of a minimal pericardial effusion which elevated the pericardium away from the heart and pulmonary vessels but did not widen the base of the pericardial sac. Straightening of the left border of the cardiac silhouette was also observed in cases in which minimal pericardial effusion remained loculated around the pulmonary conus because of multiple pericardial adhesions. Widening of the base of the heart shadow was noted with moderate to massive effusions.

In general, enlargement of the cardiac silhouette is considered to be an important sign of pericardial effusion. The differential diagnosis is, of course, between pericardial effusion and cardiac dilatation, and because of this the other signs of effusion must be present before enlargement of the cardiac shadow can be interpreted as due to pericardial effusion.

Pulmonary Inflammation. Perivascular inflammation is manifested by indistinct outline and widening of the pulmonary markings. The perivascular inflammation is present in the upper lobes as well as in the lower lobes.

Subpleural inflammation is less easy to identify roentgenographically, unless the degree of inflammation is marked. Severe subpleural inflammation causes both borders of the cardiac silhouette to appear straightened due to the inflammation of the lungs adjacent to the pericardial pleura. This obscures the cardiac shadow and makes the borders of the heart appear fuzzy. The normally sharp distinction between pleural effusion and lung may be reduced by subpleural inflammation, but this is more difficult to identify. The subpleural inflammation is not recognizable over the upper lung fields although adhesions are found at autopsy which occur in the pleura apices as well as at the bases.

Areas of interstitial pneumonia are also observed. They are small, linear, and point towards the hili. More commonly, they are present at the bases and frequently are seen to extend distally into the subpleural inflammation. If segmental areas of pneumonitis are noted, hemorrhage or infarctions or secondary pneumonia should be suspected.

Postinflammatory Changes. Segmental atelectasis follows the pattern and location of segmental pneumonitis except that the areas of atelectasis are thinner and of greater density. With time they may disappear completely or remain as fibrous strands which usually are attached to the pleura with a "tent-like" pulling of the pleura. The areas of interstitial pneumonia may disappear if complete remission occurs, but otherwise they may visualize as small thin horizontal lines in the lung bases for considerable periods of time.

Secondary Infection. Secondary bacterial pneumonia may be suspected roentgenologically if there is a diffuse pneumonitis with either unilateral or asymmetric distribution. Involvement of the upper lobes and perihilar areas is also considered to be evidence in favor of secondary infection. Resolution following antibiotic therapy usually occurs in secondary infection unless the complication is terminal. Chronic pleuritis of one base may be confused with the chronic basal changes seen in systemic lupus erythematosus; however, follow-up roentgenograms may help to establish the true nature of the process.

RESULTS

A diagnosis of systemic lupus erythema-

tosus has been made at least 56 times at the Philadelphia General Hospital since 1946, but roentgenograms for the present review were available in only 23 proved cases. Of these 23 cases, 4 were males and 19 females. Almost all were Negroes since the majority of the patients at this hospital are of the Negro race. The most common age incidence was between twenty and forty years. The total number of chest roentgenograms studied was 176. They were taken during the various stages of the disease. Because of the marked difference in the roentgen appearance at various stages, an evaluation of the individual films without consideration of the clinical history or stage of the disease was preferred in compiling the pertinent data. The following figures were obtained: enlargement of the cardiac silhouette and a change in its contour compatible with pericardial effusion were found in 94 films; widening of the base of the heart in 40 films; straightening of the left border of the cardiac silhouette in 100 films; enlargement of the heart without evidence of pericardial effusion in 7 films; unilateral pleural effusion in 21 films; bilateral pleural effusion in 73 films; prominent minor fissures in 99 films; perivascular inflammation in 93 films; subpleural inflammation in 78 films; apparent straightening of the right border of the cardiac silhouette in 44 films; segmental atelectasis, segmental pneumonitis, and/or interstitial pneumonitis in 85 films; secondary pneumonia in 10 films; and large atelectatic areas in 5 films.

Associated osseous findings were noted in only 1 out of 8 cases examined for roentgenographic evidence of joint involvement. This case had Raynaud's syndrome with distal neurologic involvement and secondary atrophy of the distal phalanges. Other joints were examined in 8 instances and were negative for arthritic changes but did show muscle wasting. Upper gastrointestinal series in 4 cases and barium enema studies in 3 cases were negative. Intravenous pyelograms in 3 cases showed normal function and in 3 other cases showed bilateral poor function. One intravenous pyelogram demonstrated unilateral function because of a renal artery thrombosis.

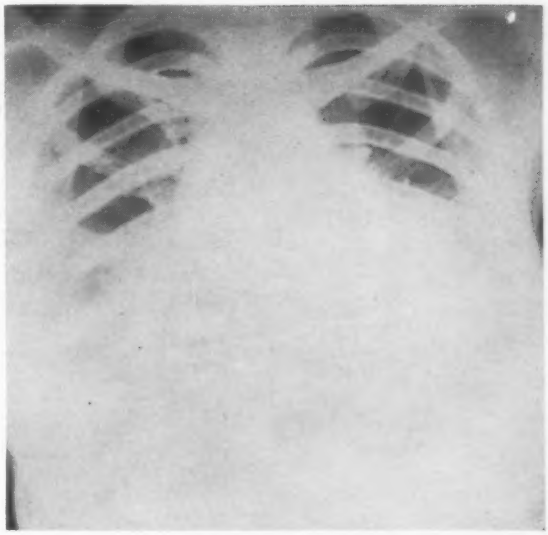

Fig. 1. Case 1 (169833). Twenty-five year old female. A roentgenogram taken a few days before death does not depict the autopsy findings. The clinical course was acute, and the patient died during the initial acute episode. It is probable that resorption of the pericardial effusion occurred just before death. Roentgenograms of the hands were negative except for Madelung's deformity.

Autopsy was performed in 12 of the 23 cases studied. A brief résumé of the findings pertinent to the roentgenologic examination in these 12 cases is given below.

Pertinent Autopsy Reports

Case 1 (169833). (Fig. 1). The heart was slightly dilated, and the pericardium was covered by dense adhesions which almost completely obliterated the pericardial sac, excepting a space which was filled with about 50 cc. of thick green effusion. The pleural space was also obliterated by adhesions, and there was a loculated pleural effusion at the right base. Lobar pneumonia was present in both lung bases. The spleen weighed 150 gm.

Case 11 (189217). (Fig. 2). The heart was normal in size. A fibrinous pericarditis was present. A few adhesions were found in the base of the pericardial sac along with 300 cc. of turbid, yellow pericardial effusion. Adhesions were numerous in the pleural spaces, and 80 cc. of pleural effusion was present bilaterally. The spleen weighed 110 gm. The lungs showed moderate

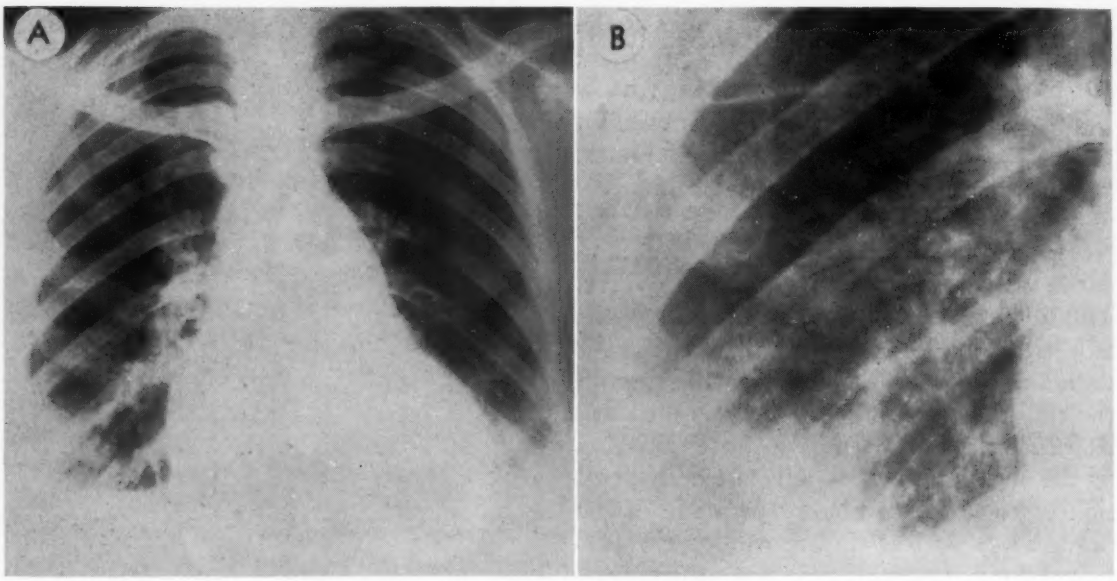

FIG. 2. Case II (189217). (*A* and *B*) Thirty-four year old female. Roentgenograms were taken a few weeks before death following a long period of nephrotic syndrome and episodes of remission and exacerbation. The patient was treated with corticoids. Note the marked straightening of the left border of the cardiac silhouette, bilateral minimal pleural effusions, perivascular infiltration, and areas of segmental pneumonitis at the bases intermixed with small linear areas of atelectasis. This represents an exacerbation superimposed on chronic disease.

interstitial fibrosis, periarterial fibrosis, congestion, hematoxylin bodies, and bronchopneumonia with pulmonary abcess.

CASE III (193017). The heart was dilated and covered by a shaggy, obliterative pericarditis; but no pericardial effusion was present. The pleural space was also obliterated by adhesions. A bronchopneumonia was found at the left lung base in the left lower lobe. Edema and peribronchial round cell infiltration were noted microscopically in the tissue specimen taken from the lung.

CASE IV (244029). The heart was slightly dilated, and the pericardium showed no adhesions. Only 90 cc. of clear yellow pericardial effusion was present. An empyema containing 2,000 cc. of purulent fluid was found in the right pleural space. A pleural effusion of 200 cc. was noted in the left pleural space. Multiple abcesses were found in the left upper lobe, and the spleen weighed 200 gm.

CASE V (259692). (Fig. 3). The left ventricle was slightly dilated. Two hundred cc. of clear yellow fluid was found in the pericardial sac. Pleural effusion amounting to 200 cc. on the left side and 400 cc. on the right side was also present. Neither pericardial nor pleural adhesions were seen. Bilateral atelectasis, congestion, edema, and patchy intra-alveolar hemor-

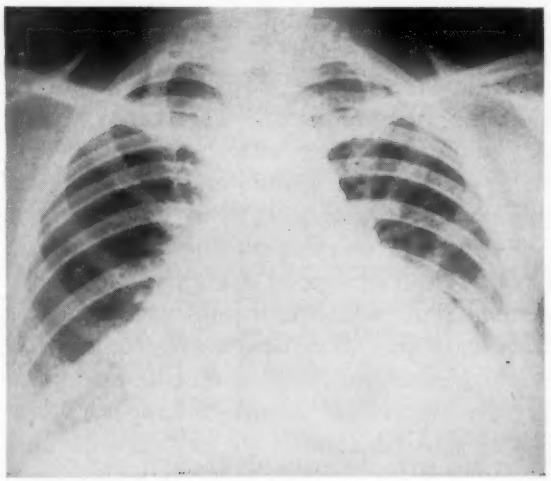

FIG. 3. Case V (259692). Twenty-three year old female. The disease was marked by a series of remissions and exacerbations. The nephrotic syndrome was present. The cardiac shadow remained enlarged at all times but varied in size. Supine roentgenograms demonstrated widening of the base of the heart on several occasions.

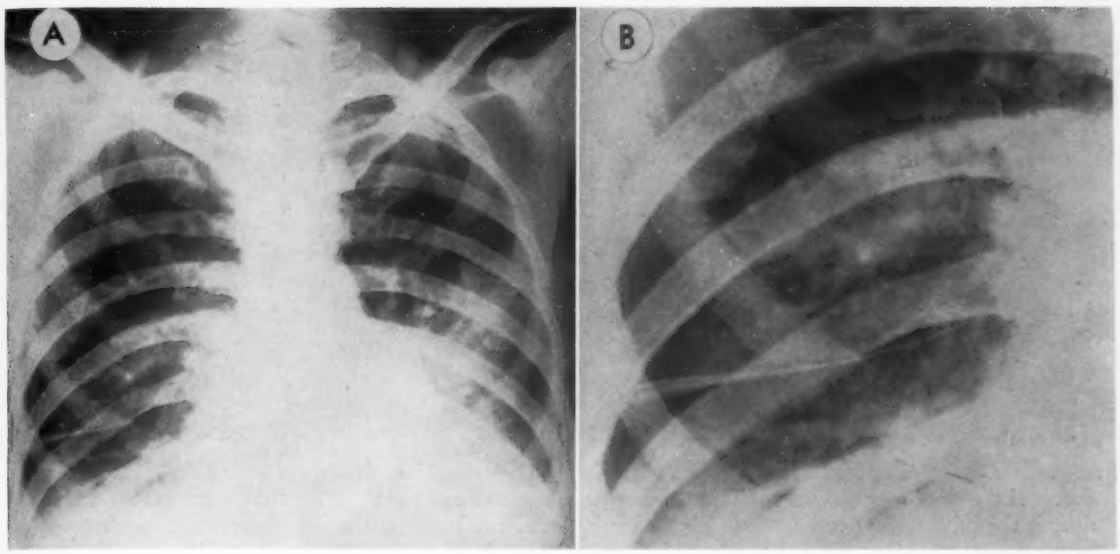

Fig. 4. Case vii (261689). (*A* and *B*) Thirty-five year old female. This patient became ill about seven months before the chest roentgenograms were taken. The films show a remarkable amount of perivascular infiltration with associated areas of segmental pneumonitis at the bases but no areas of linear atelectasis. Pleural effusion is bilateral. The area of diffuse infiltration in the left midlung field was of recent roentgenologic onset, and the patient had clinical evidence of infectious pneumonia.

rhage had involved the lungs. The spleen weighed 250 gm.

Case vi (261056). The heart was slightly enlarged. A fibrinous pericarditis was associated with 30 cc. of slightly turbid, yellow fluid. The pleura was involved by a moderate fibrinous pleuritis with 500 cc. of effusion on the left side and 30 cc. on the right side. The lungs were edematous, and bronchopneumonia was found in the left lower lobe. Microscopic examination showed a peribronchial round cell infiltration and congestion.

Case vii (261689). (Fig. 4). The heart appeared small and was surrounded by an obliterative pericardial fibrosis and minimal, gelatinous, yellow pericardial effusion. The pleura was also involved by obliterative fibrosis, and only 50 cc. of pleural effusion was found on either side. The microscopic description of the lung findings suggested interstitial mucinous edema. The spleen weighed 100 gm.

Case viii (268859). The heart was dilated. There were no pericardial adhesions, but the pericardium contained 150 cc. of yellow effusion with fibrin shreds. The pleural spaces were heavily involved by fibrosis, with complete obliteration on the right side and partial obliteration on the left side. Seven hundred cc. of pleural effusion was found in the left pleural space. Congestion and atelectasis were described in the lungs, and the spleen weighed 180 gm.

Case ix (275673). (Fig. 5). The heart was slightly dilated, and hypertrophy of the ventricular muscle had occurred. A shaggy fibrinous pericarditis covered the heart. Pericardial adhesions had formed around the base of the heart and were associated with 500 cc. of clear pericardial effusion. Thin adhesions without effusion were found in the pleural space. Congestion, edema, and bronchopneumonia were noted in the lungs. The spleen weighed 110 gm.

Case x (286824). (Fig. 6). The heart was normal in size and shape except for thickening of the ventricular muscle. Adherent pericarditis was present but no fluid. Loose adhesions were found in the pleural space with 200 cc. of fluid on the left side and 200 cc. on the right side. Congestion and bronchopneumonia were found in the lungs, and the spleen weighed 170 gm.

Case xi (296569). The heart was normal in size, and severe adhesive pericarditis without

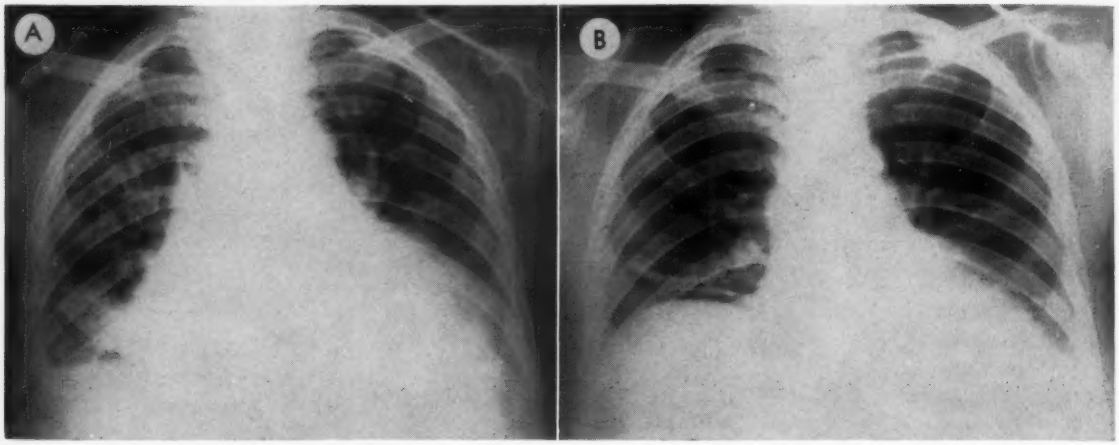

FIG. 5. Case IX (275673). (*A* and *B*) Twenty-six year old female. There is a three year interval between the first and the final roentgenogram. Renal failure was the cause of death. The initial roentgenogram, taken during the initial acute stage, shows marked subpleural and perivascular inflammation associated with a massive pericardial effusion and minimal bilateral pleural effusions. Segmental and interstitial areas of pneumonitis are also seen. On the roentgenograms taken three years later, the segmental pneumonitis has been replaced by chronic pleural scarring associated with linear areas of atelectasis at the lung bases. The pulmonary conus is obscured, but the left ventricle is prominent, and the cardiac shadow has decreased markedly in size.

effusion was seen. The pleura also was involved by multiple delicate adhesions. No pleural effusion was found. The spleen weighed 250 gm.

FIG. 6. Case X (286824). Twenty-one year old female. Roentgenogram shows straightening of the left heart border and bilateral enlargement of the cardiac silhouette. The lung fields are clear except for a few small areas of interstitial pneumonitis. Minimal pleural effusion is present at the right lung base. This probably represents the chronic stage with superimposed changes due to the nephrotic syndrome.

Miliary tuberculosis was found in the lungs as well as in other organs.

CASE XII (325287). The heart was moderately dilated and covered by an obliterative pericarditis without effusion. Multiple pleural adhesions were present with 250 cc. effusion on the right side and 350 cc. on the left side. The spleen weighed 120 gm. The lungs showed only congestion.

Two additional cases are illustrated in Figures 7 and 8 in which no autopsy was performed.

DISCUSSION

The statistical incidence of pulmonary and cardiac roentgenographic signs in systemic lupus erythematosus is difficult to evaluate. The findings in the chest roentgenograms vary markedly between examinations and are apparently related to the clinical activity. Also, the chronic changes of the lungs, pericardium, and pleura become progressively more pronounced after each acute exacerbation has subsided. Comparison with autopsy findings may be unreliable since most roentgenograms were not made during the terminal stage of the

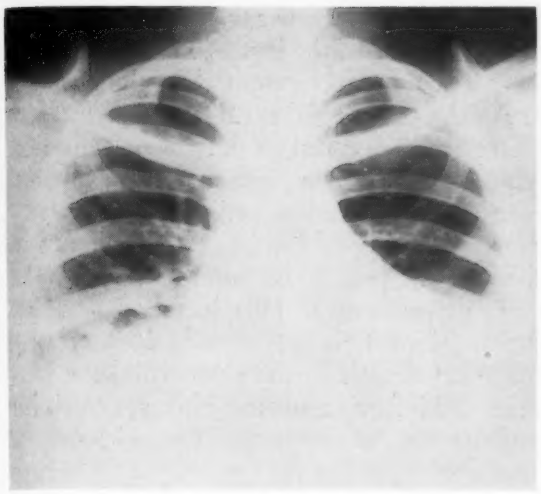

FIG. 7. (278762). Thirty-three year old female. This patient was a known hypertensive who had an acute onset of symptoms of systemic lupus erythematosus one month before the roentgenogram was taken. The chest roentgenogram shows obvious pericardial effusion with widening of the base of the heart and straightening of the left heart border. Perivascular inflammation and bilateral pleural effusions are seen. There are very small patches of interstitial pneumonitis at the lung bases.

disease, so that the same pathologic changes were not present at the time of the postmortem examination. However, if the roentgenograms exhibiting secondary complicating infections are excluded, a remarkably similar composite picture is obtained which will relate the roentgen findings with the pathologic changes and clinical stages of the disease. From a review of the case histories, chest roentgenograms and postmortem data, it is our impression that this relationship may be expressed as follows.

Initial Acute Stage. The earliest sign apparent in chest roentgenograms is an increase in the cardiac silhouette due to pericardial inflammation and effusion. The pericardial effusion may become massive in the early stages. Concomitantly or shortly afterwards, pleural effusion occurs secondary to pleural inflammation and is usually bilateral. Both pleural and pericardial effusions are clear and serous in nature in the early stages.

Next to appear is a combination of perivascular and subpleural pulmonary inflam-

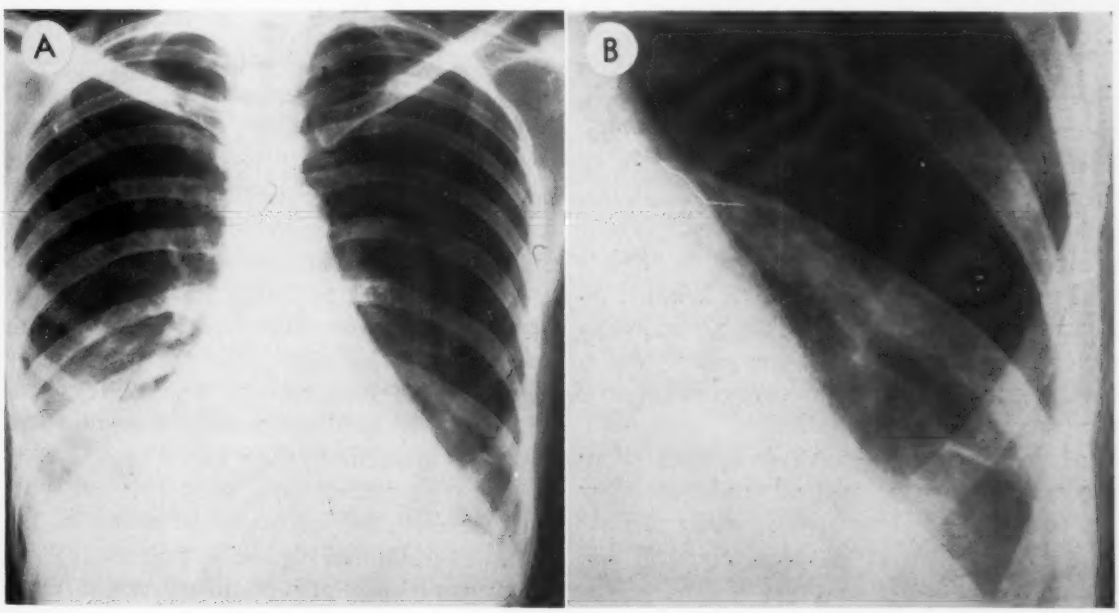

FIG. 8. (287996). (*A* and *B*) Thirty-four year old female. Roentgenograms show the chest following a remission. The lower lung fields have many linear densities, and chronic, basilar, pleural reaction is present. Both left and right borders of the cardiac silhouette appear straightened. This represents an inactive stage, but other earlier roentgenograms which are not included (because of rotation) show the acute inflammatory stage.

mation. The perivascular infiltration is universal, but the subpleural inflammation is found primarily at the lung bases and is the result of local pulmonary inflammation adjacent to the fibrinous pleural inflammation. This pleural and subpleural inflammation commonly causes the cardiac outline to appear indistinct. The subpleural inflammation along the right pericardial sac may become so intense that the right heart border appears straightened. Inflammation about the minor fissure may cause this fissure to appear thicker than normal, but this does not seem to be a reliable sign.

Small areas of interstitial and segmental pneumonitis are usually found at the lung bases and nearly coincide in time of onset with the perivascular inflammation. These small areas of pulmonary infiltration are pathologically related to areas of mucinous, interstitial edema and small areas of hemorrhage and infarction. The small hemorrhages and infarcts occur peripherally, secondary to necrosis of small peripheral pulmonary arteries.

Resolving Stage. If the patient does not die during the acute stage, a remission may occur, and the acute inflammatory changes will resolve. The pulmonary inflammation disappears first, followed by complete clearing of the interstitial mucinous edema. The small infarcts contract and leave small areas often referred to as "plate-like atelectasis," found only at the lung bases. These areas often persist for long periods of time and may change to permanent scars. Pulmonary scars, if adjacent to pleura, may cause tent-like pulling of the pleura where the pulmonary infarcts have healed and contracted towards the hili.

Multiple, thin, pleural adhesions occur secondary to the pleural inflammation. These adhesions limit the amount of fluid which can collect in the pleural spaces and frequently cause loculations of fluid at the bases. Occasionally, the pleural adhesions are so dense that only minimal fluid can collect.

The same adhesive process may also occur in the pericardial sac. When adhesions of the pericardium occur, they usually involve the base of the heart around the great vessels to a greater extent than the remainder of the pericardial sac. Usually, a moderate or small amount of pericardial effusion remains until a complete remission has occurred. The effusion ordinarily does not cause widening of the base of the heart in the upright roentgenograms except in the most acute stages. This has two possible explanations. One is that adhesions around the great vessels in the pericardial sac prevent fluid from entering this space. This explanation is supported by evidence of obliterative, adhesive pericarditis or adhesions around the base of the heart in 9 of the 12 autopsy specimens in this series. However, another possibility is that the pericardium loses its tonicity due to fibrinous degeneration of the collagen fibers, thus allowing the fluid in the pericardial sac to expand the most dependent portion of the pericardial sac only. The latter explanation is supported in certain instances by evidence of widening of the base of the heart when supine roentgenograms are compared with upright roentgenograms in the anteroposterior view.

In the later stages the pericardial and pleural effusions have a turbid, yellow, viscous appearance due to high protein content. The adhesions often limit the effusion or prevent its formation so that only small amounts of gelatinous material are found which cannot be adequately measured. Dehydration prior to death may decrease the amount of fluid found at autopsy, and conversely the nephrotic syndrome may result in an increase of its amount. Ordinarily, only small or moderate amounts of effusion are noted at autopsy.

Because endarteritis may produce partial or complete occlusion of many of the smaller pulmonary vessels, pulmonary hypertension may occur and cause the main pulmonary vessels and right ventricle to appear enlarged. However, this is usually a late change. More commonly, a slight pericardial effusion causes the right border of the cardiac silhouette to appear promi-

nent. The effusion is identified by the elevation of the pericardium in the pulmonary segment.

Chronic Stage. Following resolution, thin scars are usually observed in the inferior portions of the lungs. The cardiac silhouette may decrease in size, but more often cor pulmonale develops. If pericardial adhesions have formed, the straightening of the upper left border of the cardiac silhouette may persist. In some instances, the heart and lungs completely return to a normal appearance, but in either case there will be a definite predisposition to severe pulmonary infections which may cause death (Case IV). Recurrences are common, although occasionally remissions may prove permanent.

Exacerbation. Since most roentgenograms are taken during a period of exacerbation, acute changes are usually found superimposed on chronic changes. Pleural effusion is almost always present. The amount of effusion associated with pleuritis is variable and fluctuates markedly between examinations. In most instances the effusion is bilateral and approximately equal. Pleural thickening was never observed roentgenographically over the apices unless there was secondary infection, even though adhesions were commonly present at postmortem examination.

Due to the varying amount of pericardial effusion, the cardiac silhouette changes markedly in size; and a straightening of the left border is present to a greater or lesser degree. The heart itself becomes enlarged only after myocarditis or renal failure produces dilatation of its chambers. This enlargement of the heart was seen in our cases only in the terminal stages.

Secondary infection occurs frequently. Pneumonia, as a rule, is unilateral and is identified by the rather homogeneous opacity it casts on the roentgenogram.

LE Phenomenon in Rheumatoid Arthritis. Positive LE tests were found at the Philadelphia General Hospital in 2 patients with rheumatoid arthritis who are still living. The first patient, an adolescent female, had an acute attack of polyarthritis accompanied by acute pericarditis and roentgenograms of the chest demonstrated pericardial effusion. Within two years all of her joints had developed typical changes of rheumatoid arthritis. The cardiac size returned to normal following her first attack, and the heart and lungs have been within normal limits since. The positive LE test had reverted to negative but is again positive at the present time. The second patient, a middle aged female, had marked pulmonary fibrosis, cor pulmonale, and severe deformity of the hands with narrowing and fusion of the joints. She, too, had markedly positive LE tests. No renal biopsies were taken and neither case had skin manifestations so that these cases cannot be used to conclusively prove that systemic lupus erythematosus and rheumatoid joint changes can occur together.

These 2 cases belong to a group which differs from systemic lupus erythematosus by the destruction of articulating surfaces and by longer duration of life. The question whether to call these cases malignant rheumatoid arthritis with false positive LE tests or systemic lupus erythematosus with rheumatoid arthritis has not yet been satisfactorily answered.[26] Autopsy material in cases of this type described in the literature is either inadequately presented or lacking. However, a malignant form of rheumatoid arthritis has been reported which exhibits a clinical picture and pathologic findings closely approximating those of systemic lupus erythematosus except for lack of skin changes or "wire loop" lesions in the kidneys.[6] Slocumb[29] has called attention to the frequent occurrence of positive LE tests among cases of rheumatoid arthritis. This finding has been confirmed recently by other investigators.[9,22] Perhaps it would be advisable to re-evaluate those cases having roentgenologic findings of destructive joint changes which, on the basis of positive LE tests, have been diagnosed as proved instances of systemic lupus erythematosus. These cases should be accepted as proved only if skin changes are present clinically or

renal wire loop lesions are demonstrated pathologically. Roentgenologic evidence of destructive joint changes is indicative of rheumatoid arthritis and should be considered as such in spite of positive LE tests until irrefutable evidence is produced to prove that systemic lupus erythematosus and rheumatoid arthritis may be associated.

Differential Diagnosis. The straightening of the left border of the cardiac silhouette, caused by small amounts of pericardial effusion, is an important roentgenologic sign. This sign will often permit differentiation from Boeck's sarcoid, idiopathic cardiac hypertrophy (previously often referred to as beri-beri heart), cor pulmonale with chronic infection at the lung bases, hyperthyroidism with secondary heart failure, rheumatic heart disease, etc. Periarteritis nodosa in the acute stage and systemic lupus erythematosus cannot be differentiated; however, in the chronic stage of periarteritis, the pulmonary conus will be very prominent due to cor pulmonale and thus it will permit differentiation in most instances from the straightening of the left border of the cardiac silhouette of systemic lupus erythematosus. In hypothyroidism associated with a pericardial effusion this straightening may be indistinguishable.

SUMMARY

1. The roentgen findings in systemic lupus erythematosus depend on the stage of the disease during which the roentgenograms are taken.

2. Changes visible in the chest roentgenograms may suggest the correct diagnosis. These changes are:

Initial Acute Stage: Bilateral moderate or massive pleural effusion; massive pericardial effusion; subpleural inflammation; perivascular inflammation; small areas of interstitial pneumonitis at the lung bases; small areas of segmental pneumonitis at the lung bases.

Resolving Stage: Minimal unilateral or bilateral pleural effusion: minimal to moderate pericardial effusion with straightening of the left border of the cardiac silhouette but without widening of the heart base; small linear areas of "plate-like" atelectasis at the lung bases; areas of segmental atelectasis at the lung bases.

Chronic Stage: Unless the nephrotic syndrome is present, the cardiac contour returns to normal or cor pulmonale develops. In some instances the outline of the pulmonary conus remains partly obscured by fibrosis which fills in the pericardial spaces around the conus. The pleural effusion may completely disappear. Fine pulmonary scars may be seen at the lung bases frequently associated with "tenting" of the pleura, or the lungs may appear clear. Multiple pulmonary infections occur.

Exacerbation: Pleural and pericardial effusions are limited by adhesions; fine linear densities are intermingled with small areas of interstitial pneumonia at the lung bases; basal areas of segmental pneumonitis occur; subpleural and perivascular inflammation is present.

3. Delayed renal function may be evident on intravenous pyelography.

4. The relationship between systemic lupus erythematosus and destructive joint changes typical of rheumatoid arthritis is unproved. In the cases of this series, there were no instances of demonstrable joint changes other than soft tissue edema and those changes attributable to Raynaud's syndrome.

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REFERENCES

1. Aitchison, J. D., and Williams, A. W. Pulmonary changes in disseminated lupus erythematosus. *Ann. Rheumat. Dis.*, 1956, *15*, 26–32.

2. Baggenstoss, A. H. Symposium on systemic lupus erythematosus; visceral lesions in disseminated lupus erythematosus. *Proc. Staff Meet., Mayo Clin.*, 1952, *27*, 412–419.

3. BAEHR, G., KLEMPERER, P., and SCHIFRIN, A. Diffuse disease of peripheral circulation usually associated with lupus erythematosus and endocarditis. *Tr. A. Am. Physicians*, 1935, *50*, 139–155.
4. BERMAN, L., AXELROD, A. R., GOODMAN, H. L., and MCCLAUGHRY, R. I. So-called "lupus erythematosus inclusion phenomenon" of bone marrow and blood; morphologic and serologic studies. *Am. J. Clin. Path.*, 1950, *20*, 403–418.
5. BENNETT, G. A., and DALLENBACH, F. D. Synovial membrane changes in disseminated lupus erythematosus; observations of 2 autopsied cases. *Mil. Surgeon*, 1951, *109*, 531–539.
6. BEVANS, M., NADELL, J., DEMARTINI, F. E., and RAGAN, C. Systemic lesions of malignant rheumatoid arthritis. *Am. J. Med.*, 1954, *16*, 197–211.
7. DUSTAN, H. P., TAYLOR, R. D., CORCORAN, A. C., and PAGE, I. H. Rheumatic and febrile syndrome during prolonged hydralazine treatment. *J.A.M.A.*, 1954, *154*, 23–29.
8. FOLDES, J. Acute systemic lupus erythematosus. *Am. J. Clin. Path.*, 1946, *16*, 160–173.
9. FRIEDMAN, I. A., SICKLEY, J. F., POSKE, R. M., BLACK, A., BRONSKY, D., HARTZ, W. H., JR., FELDHAKE, C., REEDER, P. S., and KATZ, E. M. The L. E. phenomenon in rheumatoid arthritis. *Ann. Int. Med.*, 1957, *46*, 1113–1136.
10. GLAGOV, S., and GECHMAN, E. Familial occurrence of disseminated lupus erythematosus. *New England J. Med.*, 1956, *255*, 936–940.
11. GOULD, D. M., and DAVES, M. L. Roentgenologic findings in systemic lupus erythematosus; analysis of 100 cases. *J. Chron. Dis.*, 1955, *2*, 136–145.
12. HARVEY, A. M., SHULMAN, L. E., TUMULTY, P. A., CONLEY, C. L., and SCHOENRICH, E. H. Systemic lupus erythematosus: Review of literature and clinical analysis of 138 cases. *Medicine*, 1954, *33*, 291–437.
13. HASERICK, J. R. Modern concepts of systemic lupus erythematosus: Review of 126 cases. *J. Chron. Dis.*, 1955, *1*, 317–334.
14. ISRAEL, H. L. Pulmonary manifestations of disseminated lupus erythematosus. *Am. J. M. Sc.*, 1953, *226*, 387–392.
15. KLEMPERER, P., GUEFT, B., LEE, S. L., LEUCHTENBERGER, C., and POLLISTER, A. W. Cytochemical changes of acute lupus erythematosus. *Arch. Path.*, 1950, *49*, 503–516.
16. KLEMPERER, P., POLLACK, A. D., and BAEHR, G. Pathology of disseminated lupus erythematosus. *Arch. Path.*, 1941, *32*, 569–631.
17. KUSHNIRUK, W. Systemic involvement in chronic lupus erythematosus. *Canad. M.A.J.*, 1957, *76*, 184–193.
18. KUZMA, J. F. Pulmonary changes in collagen diseases. *Dis. Chest*, 1957, *32*, 265–273.
19. LIBMAN, E., and SACKS, B. Hitherto undescribed form of valvular and mural endocarditis. *Arch. Int. Med.*, 1924, *33*, 701–737.
20. LOWMAN, E. W. Muscle, nerve, and synovial changes in lupus erythematosus. *Ann. Rheumat. Dis.*, 1951, *10*, 16–21.
21. MOERSCH, H. J., PURNELL, D. C., and GOOD, C. A. Pulmonary changes occurring in disseminated lupus erythematosus. *Dis. Chest*, 1956, *29*, 166–173.
22. PARR, L. J. A., SHIPTON, E. A., BENJAMIN, P., and WHITE, P. H. The L. E. phenomenon in rheumatoid arthritis. *M. J. Australia*, 1957, *44*, 900–905.
23. PERRY, H. M., JR., and SCHROEDER, H. A. Syndrome simulating collagen disease caused by hydralazine (Apresoline). *J.A.M.A.*, 1954, *154*, 670–673.
24. Personal observation.
25. PURNELL, D. C., BAGGENSTOSS, A. H., and OLSEN, A. M. Pulmonary lesions in disseminated lupus erythematosus. *Ann. Int. Med.*, 1955, *42*, 619–628.
26. RAGAN, C. Relationship of rheumatoid arthritis to periarteritis nodosa and systemic lupus erythematosus. *J. Chron. Dis.*, 1957, *5*, 688–696.
27. RAKOV, H. L., and TAYLOR, J. S. Acute disseminated lupus erythematosus, without cutaneous manifestations and with heretofore undescribed pulmonary lesions. *Arch. Int. Med.*, 1942, *70*, 88–100.
28. REICHES, A. J. Lupus erythematosus syndrome: Relationship of discoid (cutaneous) lupus erythematosus to systemic (disseminated) lupus erythematosus. *Ann. Int. Med.*, 1957, *46*, 678–684.
29. SLOCUMB, C. H. Symposium on certain problems arising from clinical use of cortisone; rheumatic complaints during chronic hypercortisonism and syndromes during withdrawal of cortisone in rheumatic patients. *Proc. Staff Meet., Mayo Clin.*, 1953, *28*, 655–657.
30. STICKNEY, J. M., and KEITH, N. M. Renal involvement in disseminated lupus erythematosus. *Arch. Int. Med.*, 1940, *66*, 643–660.
31. TEILUM, G. Pathogenetic studies on lupus erythematosus disseminatus and related diseases. *Acta med. scandinav.*, 1946, *123*, 126–142.
32. THORELL, I. Pulmonary changes in cases of disseminated lupus erythematosus. *Acta radiol.*, 1952, *37*, 8–16.

MEDIASTINAL BRONCHOGENIC CARCINOMA*

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THE protean clinical and roentgenographic manifestations of bronchogenic carcinoma have been duly recorded in recent years.[1,2,4,6–9,13] Little stress, however, has been placed on the primary mediastinal involvement by this tumor. A bronchogenic neoplasm may often present on the initial roentgenographic examination as a large, round and often symmetric mediastinal mass.

Three cases have been encountered in our recent experience which fall into a definite syndrome complex as evidenced by the clinical history, hospital course, roentgenographic and pathologic findings.

REPORT OF CASES

CASE 1 (Fig. 1 and 2). H. C., a forty-four year old white male, was admitted to Kings County Hospital on January 29, 1956 with a one year history of cough productive of brownish sputum which on occasion was blood streaked. A month prior to admission the cough became "more hacking in character," as well as mucoid.

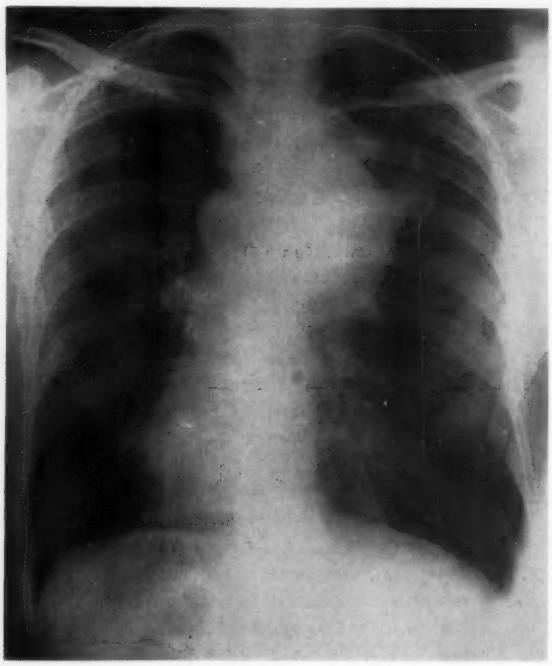

FIG. 1. Case 1. Posteroanterior roentgenogram showing a mediastinal mass with tracheal compression.

FIG. 2. Case 1. Lateral projection. The mediastinal mass is located posteriorly compressing the trachea.

One week previously he noted marked shortness of breath, upper chest pain and marked weakness. There was no history of chills, fever or night sweats. Past history elicited rheumatic fever in childhood. The patient smoked one to two packages of cigarettes daily for twenty years. Physical examination on admission showed an afebrile male in acute distress with dyspnea and cyanosis. The neck veins were dis-

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tended. The lungs revealed inspiratory and expiratory wheezes throughout all fields with subcrepitant and sonorous râles at both lung bases. There was a systolic murmur heard over the entire precordium. The liver was enlarged to 2 fingerbreadths below the right costal margin in the midclavicular line and was nontender. There was a trace of ankle edema, but no clubbing of the fingers. The positive laboratory findings were leukocytosis, elevated venous pressure, prolonged circulation time (arm to tongue) and right axis deviation with myocardial damage on electrocardiographic examination. The normal or negative findings included hemoglobin, urinalysis, blood urea nitrogen, fasting blood sugar, CO_2 combining power and serum electrolytes. Sputum cytologic examination revealed nondiagnostic atypical cells.

Hospital Course. The patient was treated on admission for acute pulmonary edema with positive pressure oxygen, morphine, digitalis, mercurial diuretics and phlebotomy. After improvement he was maintained on digitalis, sedation, penicillin, streptomycin, aleurone and vaponefrin aerosol regimen. Three days after hospitalization a tracheostomy was performed because of recurring dyspnea and cyanosis. His condition grew gradually worse and he expired on the thirteenth hospital day. Consent for autopsy was not obtained.

Case II (Fig. 3 and 4). A. M., a seventy year old white male, was admitted to Kings County Hospital on December 19, 1955 with a five month history of hoarseness, nonproductive cough, boring left chest pain and progressive shortness of breath. Ear, nose and throat evaluation at this time revealed left vocal cord paralysis. For the three weeks prior to admission the patient noted difficulty in swallowing solid foods and an occasional chest wheeze. There was no history of chills, fever, hemoptysis or peripheral edema.

Physical examination revealed a well developed male in acute distress, unable to be flat in bed. His pulse was 120 and irregular, temperature 99°F., blood pressure 100/60 and respiratory rate was 40 per minute. Eye, ear, nose and throat examinations were not remarkable. The chest was emphysematous with decreased breath sounds and coarse rhonchi throughout both upper lobes. The heart, abdominal and neurologic findings were within normal limits. There was no clubbing of the fingers or cyanosis.

Past history revealed bilateral upper lobe tu-

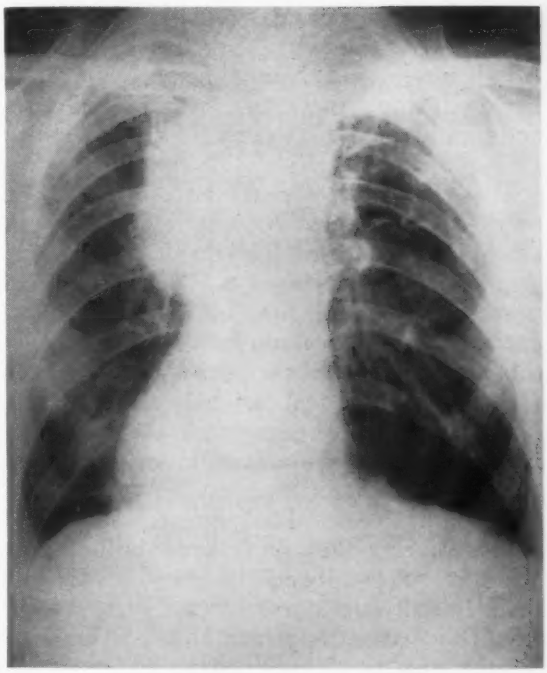

Fig. 3. Case II. Posteroanterior roentgenogram of the chest showing a mediastinal mass.

Fig. 4. Case II. Lateral roentgenogram demonstrates esophageal and tracheal compression by a posterior mediastinal mass.

berculosis twenty years previously with no evidence of recent activity.

Laboratory data: Normal hemoglobin, white blood cell count, urinalysis, fasting blood sugar and total protein A/G ratio. The serologic test for syphilis was negative. The blood urea nitrogen was 30 mg. per cent and the circulation time (decholin—arm to tongue) was twenty seconds. An electrocardiogram showed first degree heart block, delayed A-V conduction and myocardial damage. Sputum culture revealed *Staphylococcus aureus* and *Streptococcus*. Sputum and gastric cultures on two occasions each were negative for acid fast bacteria. Two sputum specimens were reported suspicious for malignant cells and one sputum was conclusive for anaplastic carcinoma.

Hospital Course. The patient was treated with intravenous fluids, oxygen, sedation, ephedrine, alevaire, vaponefrin, streptomycin and PAS. Initially there was marked symptomatic relief. The patient remained afebrile. However, on the twelfth hospital day he developed marked dyspnea and cyanosis. Despite a tracheostomy he became increasingly lethargic, finally comatose and died the following day.

Autopsy revealed an anaplastic carcinoma of the left upper lobe with extension into the mediastinum. There was associated pulmonary congestion and fibrosis with generalized arteriosclerosis.

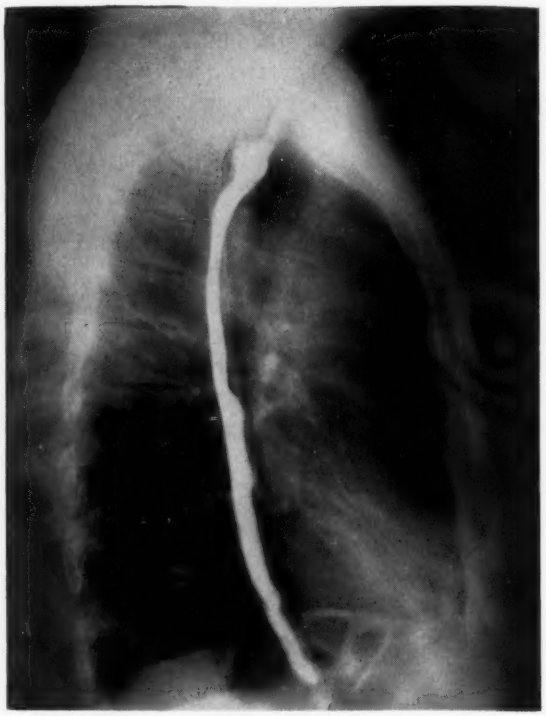

Fig. 6. Case III. Lateral roentgenogram shows the mediastinal mass located anteriorly with some tracheal encroachment.

Case III (Fig. 5, 6 and 7). E. H., a forty-seven year old white male, was admitted to Kings County Hospital on May 10, 1955 with a four month history of hoarseness. Examination four months previously (at another hospital) revealed left vocal cord paralysis. Bronchoscopy

Fig. 5. Case III. Posteroanterior view. Fusiform mediastinal mass with tracheal deviation.

Fig. 7. Case III. Posteroanterior view. Progressive enlargement of the mediastinal mass.

and chest roentgenograms were reported as negative. Several months later he began to have daily temperature elevations up to 103–104°F. A chest roentgenogram (elsewhere) revealed a "mediastinal mass." A course of nitrogen mustard and radiation therapy produced no response.

Past history revealed the patient to have had a mild chronic cough and a known inactive left apical tuberculous lesion.

Physical examination on admission to Kings County Hospital showed an afebrile male with a pulse of 94 and a respiratory rate of 24 per minute. There was no significant positive physical findings. Laboratory data demonstrated a moderate anemia (7.5 to 10 gm.) and leukocytosis (14,500–20,000). The normal or negative data included urinalysis, blood urea nitrogen, serum calcium, serum phosphorus, CO_2 combining power, serum electrolytes, and electrocardiogram.

Two angiocardiograms were interpreted as being compatible with aneurysm of the uppe-arch of the aorta, ascending aorta and innomir nate artery. The patient ran a progressively downhill course with daily febrile episodes. Despite blood transfusions, penicillin, terramycin and supportive measures, he expired three months after his final admission.

Autopsy revealed a bronchogenic carcinoma, oat cell type, of the left upper lobe with massive mediastinal metastasis.

ADDITIONAL CASES FROM THE LITERATURE

Shandalow[12] described a case of bronchogenic carcinoma simulating an aortic lesion. Pertinent data included a paralysis of the left vocal cord, clubbing of the fingers and elevated sedimentation rate. Laminagraphic studies of the chest revealed a mass with some degree of lobulation occupying the entire mediastinum. Bronchoscopic examination, Papanicolaou studies and scalene lymph node biopsy were noncontributory. At surgical exploration a 10 cm. mass apparently arising from the left upper lobe bronchus had extended into the mediastinum. The pathologic diagnosis was anaplastic bronchogenic carcinoma.

In the case presentation of the Massachusetts General Hospital in January, 1956,[3] a fifty-five year old white male was seen with a four month history of dysphagia and weight loss and more recent onset of cough, dyspnea, wheeze, mucoid and blood tinged sputum. A mass occupying the posterior superior mediastinum was found on roentgenographic examination of the chest. The patient died suddenly two days after admission. Autopsy findings revealed an undifferentiated carcinoma of the left upper lobe with widespread mediastinal extension.

Strode's[16] Case No. 8 was a carcinoma of the mediastinum probably originating from the right upper lung which resulted in a superior vena cava obstruction.

DISCUSSION

ROENTGEN FINDINGS

In the so-called mediastinal bronchogenic new growth, the primary site of the disease is in the main stem and lobar bronchus. The oat or anaplastic cell is found chiefly in these bronchi. The tumor is highly invasive, extending rapidly along the bronchus to involve the mediastinal structures. The presenting roentgenographic finding is frequently a mass which appears to involve the mediastinum symmetrically or eccentrically. In its early stage of development, because the main stem bronchus is overlapped by the heart and great vessels, the tumor does not produce a shadow detectable on the roentgenogram. However, bronchoscopy may reveal the presence of a tumor which can be confirmed by biopsy or smear of the lesion. When the obstruction of the bronchus becomes more advanced and drainage is impaired, secondary changes in the lung are noted, leading to segmental atelectasis, pneumonitis or abscess formation. Often the carcinoma invades the pulmonary artery and anterior vein which lie in close proximity to the main stem bronchus.

The 3 cases presented here clearly demonstrate the extent and manner in which the mediastinum becomes involved. The tumor may invade the anterior, middle or posterior mediastinum with compression of the vital structures. Roentgenographically, the mass is frequently mistaken for aneurysm, lymphoma or some other type of mediastinal tumor.

In Case I a large well defined rounded mass was noted in the mediastinum, extending outwards into the right lung field. Its outer border was sharp and appeared to merge with the ascending aorta. There was asymmetric enlargement of the mediastinum and the density produced a segmental collapse of the anterior segment of the right upper lobe. In the lateral projection, the tumor filled the anterior, middle and posterior mediastinum with marked compression of the trachea.

In Case II a large mass in the posteroanterior projection symmetrically involved the mediastinum extending somewhat more to the left without evidence of lung compression. The partially opacified esophagus was markedly displaced to the right and compressed to a degree where little barium passed beyond the point of maximum obstruction. In the lateral view the entire mediastinum was invaded. There was marked narrowing of the trachea and esophagus at the level of the hilar shadows. This is an excellent example of a mediastinal tumor without demonstrable lung involvement which proved to be a bronchogenic carcinoma. The roentgen findings could well be interpreted as those of lymphoma or some other type of mediastinal tumor.

Case III presented a symmetric fusiform widening of the mediastinum in the posteroanterior view, somewhat more prominent on the right, with slight displacement of the trachea. There was no pulmonary or pleural involvement. In the lateral projection, a large density was seen in the anterior mediastinum. The opacified esophagus was not encroached upon or displaced. Subsequent studies revealed an enlarging mediastinal mass which ultimately became extensive and involved vital structures. This type of mediastinal enlargement could well be interpreted as early diffuse aneurysm of the ascending aorta and proximal portion of the arch. Angiocardiographic studies were done in one institution because the findings were highly suggestive of aneurysmal formation of the aorta.

CLINICAL DATA

History. The cases reviewed indicated the gradual onset of symptoms four to twleve months prior to hospitalization. The most common complaints were (1) cough, which may be productive of a mucoid or blood tinged sputum, (2) progressive dyspnea, (3) hoarseness with vocal cord paralysis and (4) chest pain. Fever, weakness, weight loss, wheeze, and difficulty in swallowing may be present.

It is of interest to note the past history of pulmonary tuberculosis in 2 of the cases.

Physical Examination. Most commonly encountered were acutely and chronically ill patients with marked dyspnea and cyanosis. The lung fields usually revealed adventitious sounds, most frequently rhonchi and wheezes.

Hospital Course. This was marked by a progression of the symptomatology and most commonly sudden death.

Differential Diagnosis. The differential diagnosis should include the malignant tumors of the anterior or posterior mediastinum;[11] namely, primary carcinoma of the mediastinum, sarcoma, hemangio-endothelioma, lymphoma, and in addition aortic aneurysms,[5] and subclinical coarctation of the aorta.[14]

The above lesions are often indistinguishable ante mortem or preoperatively although special studies including laminagraphy of the chest[10] and angiocardiography[15] may aid in establishing a tentative diagnosis.

SUMMARY

Bronchogenic carcinoma must be considered in the differential diagnosis of mediastinal masses. The roentgenologic aspects of this lesion are presented. Clinical evidence of the disease process may be present for many months; however, death frequently occurs suddenly. The differential diagnosis is briefly discussed.

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REFERENCES

1. Beeber, T. T., Jr., and Irey, N. S. Bronchogenic carcinoma; study of fifty autopsied cases. *Dis. Chest*, 1950, *18*, 61–80.
2. Carr, D., Skinner, E. F., Robbins, S. G., and Kessler, C. R. Primary neoplasms of lung. *Dis. Chest*, 1950, *17*, 618–643.
3. Case Records of the Massachusetts General Hospital. Case 42031. *New England J. Med.*, 1956, *254*, 126–129.
4. Ehler, A., Stranahan, A., and Olson, K. B. Bronchogenic carcinoma; study of 517 cases. *New England J. Med.*, 1954, *251*, 207–213.
5. Fullenlove, T. M. Case reports; sacculated aortic aneurysm; report of case mistaken for mediastinal tumor with metastases. *Radiology*, 1942, *38*, 86–89.
6. Hinshaw, H. C., and Corwin, H. Diseases of the Chest. W. B. Saunders Company, Philadelphia, 1956.
7. Hollingsworth, R. K. Bronchiogenic carcinoma; analysis of 343 cases. *Ann. Int. Med.*, 1947, *26*, 377–385.
8. Moersch, H. J., and McDonald, J. R. Significance of cell types in bronchogenic carcinoma. *Dis. Chest*, 1953, *23*, 621–633.
9. Ochsner, A., Ray, C. J., and Acree, P. W. Cancer of lung; review of experiences with 1,457 cases of bronchogenic carcinoma. *Am. Rev. Tuberc.*, 1954, *70*, 763–783.
10. Scott, W. G., Moore, S., and Russell, T. G. Body section radiography in diagnosis of aortic aneurysms and mediastinal tumors. *South M. J.*, 1941, *34*, 343–351.
11. Seiler, H. H. Classification and diagnosis of mediastinal tumors. *J. Florida M. A.*, 1955, *42*, 374–382.
12. Shandalow, S. L. Bronchogenic carcinoma simulating aneurysm of thoracic aorta. *Am. J. Surg.*, 1955, *90*, 1024–1026.
13. Shaw, R. R. Early detection of bronchogenic carcinoma. *Dis. Chest*, 1950, *18*, 185–197.
14. Souders, C. R., Pearson, C. M., and Adams, H. D. Aortic deformity simulating mediastinal tumor: subclinical form of coarctation. *Dis. Chest*, 1951, *20*, 35–45.
15. Steinberg, I., Robb, G. P., and Roche, U. J. Differential diagnosis of mediastinal tumor and aortic aneurysm; value of contrast cardiovascular visualization. *New York State J. Med.*, 1940, *40*, 1168–1177.
16. Strode, J. E. Tumors of chest lying within or adjacent to mediastinum. *Hawaii M. J.*, 1947, *7*, 109–117.

DIAPHRAGMATIC CHANGES INCIDENT TO HEPATIC NEOPLASMS*

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THE roentgenologic diagnosis of liver metastases may be aided by changes in the position, configuration and range of motion of the right diaphragm. The present report describes observations on 25 patients with liver metastases thus identified roentgenologically and confirmed at operation, necropsy or both. Twelve were women, and all were from forty to seventy-five years old. Nine came to necropsy. The primary tumors were in the gastrointestinal tract in 10, in the breast in 6, and in the gallbladder in 3. Two patients had hepatomas, and neoplasms of the ovary, uterus and pancreas were encountered in one patient each. In one patient the primary tumor could not be found. Twenty-one were known cancer patients. In 4 the tumor was unsuspected until disclosed at operation even though the presence of liver metastases was suspected from the roentgenologic examination of the diaphragm. This occurred in both patients with hepatoma, in one with a primary carcinoma of the gallbladder and in another with a pancreatic carcinoma.

Physical examination disclosed marked hepatomegaly in 9 patients. In 10 others the liver edge was palpated from 1 to 4 fingerbreadths beneath the right costal arch. In the remaining 6 the existence of hepatomegaly could not be established clinically. In 3 patients a diagnosis of right pleural effusion had been made because of dullness over the right chest incident to the elevation of the diaphragm.

The roentgenologic investigations included fluoroscopic and roentgenographic studies of the chest and roentgenkymographic examinations of the diaphragm. The latter procedure permits accurate measurement of the range of motion and the respiratory wave forms of both diaphragms, and has the advantage of being a permanent record which can be studied repeatedly and objectively. The exposure to radiation of both the examiner and the patient is diminished.

The chest roentgenograms were obtained at midinspiration. Comparison of the right and left diaphragm showed the right to be higher than the left by from 1 to 2 cm. in 5 patients. In 3 of these both diaphragms were elevated. In 8 the dome of the right diaphragm was from 2 to 4 cm. higher than the left and in 12 it was from 4 to 6 cm. higher. The configuration of the elevated right diaphragm was of particular interest because of a bulging appearance, with the lateral aspect of the diaphragm elevated. The right costophrenic sinus was shorter than the left in 18, and either equal or somewhat deeper than the left in 7. Elevation of the right diaphragm was not accompanied by pulmonary or pleural changes in 22 patients. In the remaining 3 there was a slight pleural reaction. Two of them had concomitant right lower lobe metastases.

The respiratory range of the diaphragm was studied fluoroscopically and by means of roentgenkymography. Fluoroscopic observations were made whenever possible by more than one examiner, and it was not infrequent to find dissimilar notes. The roentgenkymograms recorded from 1 to 3 respiratory excursions with moderately forced breaths over a three second period. Inasmuch as the fluoroscopic notes were quite subjective, and the kymograms are completely objective, the latter procedure was regarded as more accurate even though it is recognized that careful fluoroscopic inspection may be equally reliable for estimating the range of diaphragmatic movement. Normally the right diaphragm often is slightly higher than the left and its motion

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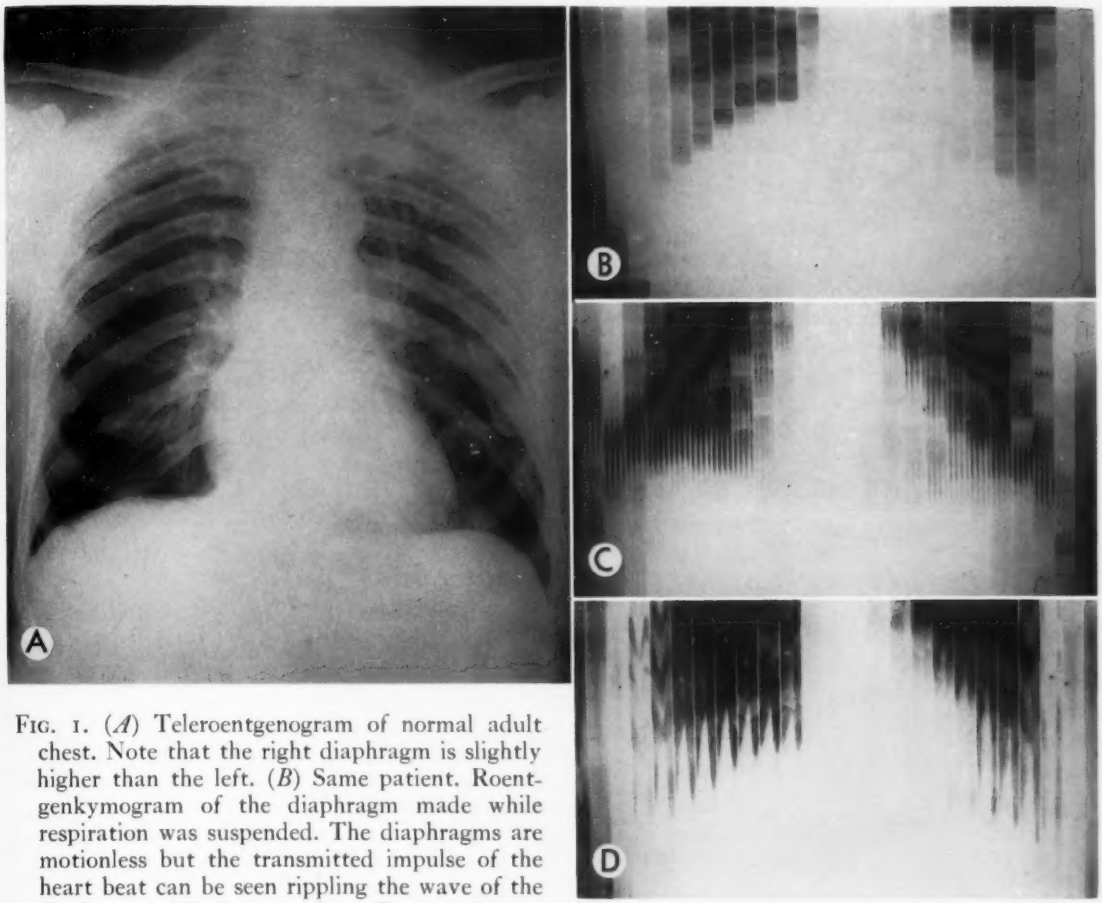

FIG. 1. (*A*) Teleroentgenogram of normal adult chest. Note that the right diaphragm is slightly higher than the left. (*B*) Same patient. Roentgenkymogram of the diaphragm made while respiration was suspended. The diaphragms are motionless but the transmitted impulse of the heart beat can be seen rippling the wave of the diaphragm. (*C*) Same patient. Roentgenkymographic examination of the diaphragm recording 3 waves. The excursions of the diaphragm are reflected in the configuration of the heart. (*D*) Same patient. Roentgenkymogram recording single wave.

somewhat less. For this reason elevation of the right diaphragm up to about 2.5 cm. above the left, and restriction of motion of less than 25 per cent were regarded as of doubtful significance. When the right diaphragm was from 3 to 5 cm. above the left and its motion restricted 50 per cent or more, the possibility of underlying hepatic metastases was suggested. Impairment of motion and elevation of both diaphragms are difficult to evaluate, but should be regarded as suggestive of a lesion of sufficient size to cause this change.

The liver was inspected at operation in 19 cases, and the presence of an enlarged or nodular liver due to hepatic metastases was verified, but invasion of the capsule of Glisson and the diaphragm could not be determined with certainty. However, the necropsy observations in 9 patients suggested the mechanism whereby the diaphragm changed its normal position and movement. The liver weights varied from 2,000 to 4,000 gm. Three weighed slightly less than 2,500 gm., and the others ranged from 3,000 to 4,000 gm. The bulk of the tumefied liver alone accounted for restriction of movement of the right diaphragm in 4 patients. In these the convex upward bulging of the dome of the liver resulted in the change in the configuration of the diaphragm, even though there was no invasion of the diaphragmatic lining or muscle. In 3 patients the tumor in the dome of the liver extended through the capsule of Glisson and was fixed by dense fibrous and fibrin-

ous adhesions to the peritoneal surface of the diaphragm. In 2 others the tumor not only penetrated Glisson's capsule but invaded and replaced the musculature of the diaphragm. In 2 patients the liver extended well to the left of the midline, apparently restricting the motion of both diaphragms.

REPORT OF CASES

CASE 1. A. S., a sixty-seven year old white male, was admitted because of dull, persistent nonradiating pain in the right lower chest of two days' duration. No cough, chills or fever were present. A history of chronic alcoholism was elicited. Physical examination disclosed some crepitant rales over both bases. The liver edge was sharp, smooth, and nontender, and was felt 3 fingerbreadths below the costal margin. The clinical impression at that time was pleurisy and hepatomegaly of unknown origin.

Teleroentgenographic examination of the chest (Fig. 2*A*) showed the right diaphragm to be 4 cm. higher than the left, with a bulging upward convexity and shortened costophrenic sinus. The lungs were normal. Fluoroscopic and roentgenkymographic studies showed the motion of the right diaphragm to be restricted about 75 per cent (Fig. 2*B*).

The patient became slightly jaundiced while in the hospital. A history of a brief episode of jaundice several months before admission was

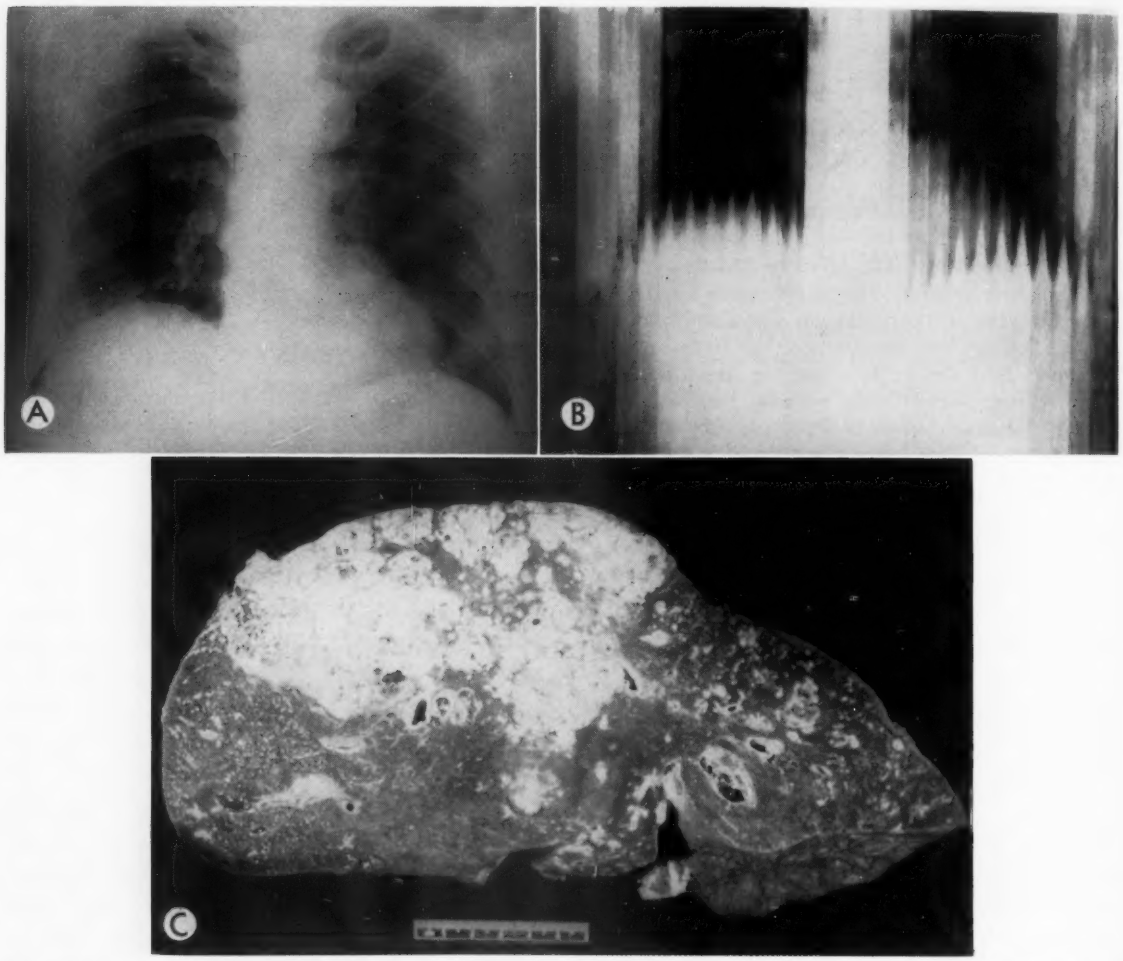

FIG. 2. Case 1. (*A*) Teleroentgenogram of the chest showing elevation and bulging of the right leaf of the diaphragm. Note that the costophrenic sinus is deeper than on the contralateral side. The lung fields are clear. (*B*) Roentgenkymogram of diaphragm recording 1.5 waves. Note that the motion of the right diaphragm is restricted by somewhat more than one-half as compared with the left diaphragm. The wave form itself is not grossly disturbed. (*C*) Specimen of liver removed at necropsy showing extensive neoplastic invasion of dome of right diaphragm. The pathologic diagnosis was hepatoma.

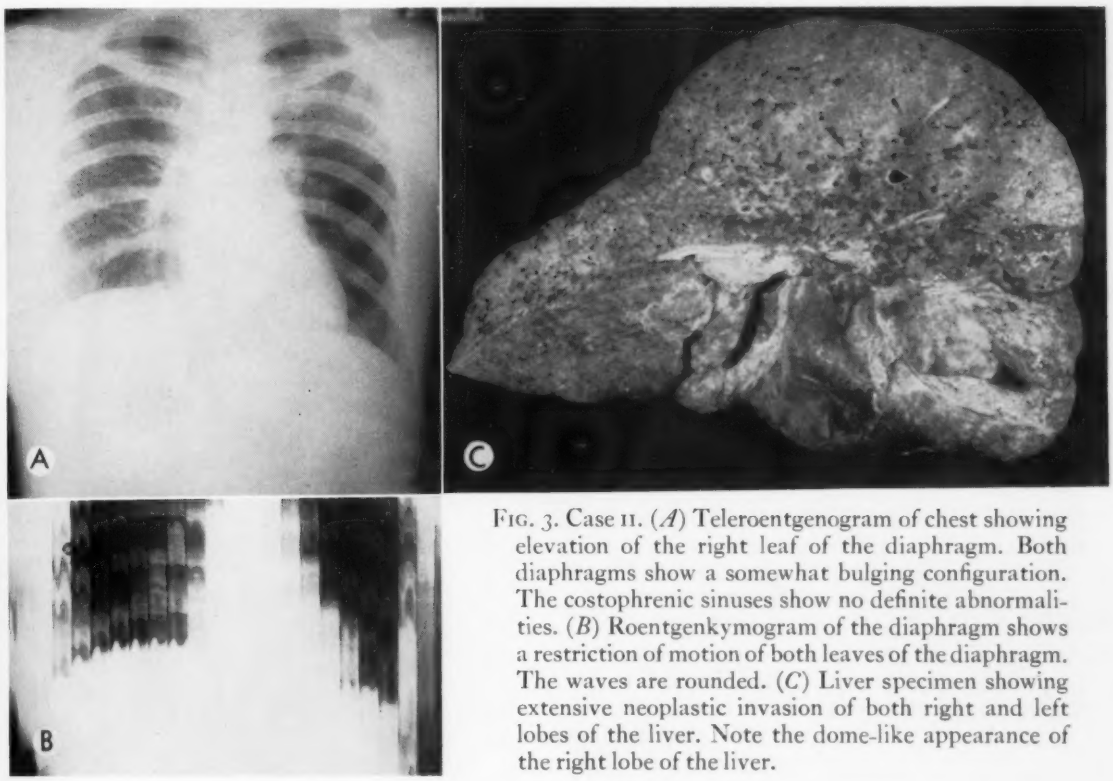

Fig. 3. Case II. (*A*) Teleroentgenogram of chest showing elevation of the right leaf of the diaphragm. Both diaphragms show a somewhat bulging configuration. The costophrenic sinuses show no definite abnormalities. (*B*) Roentgenkymogram of the diaphragm shows a restriction of motion of both leaves of the diaphragm. The waves are rounded. (*C*) Liver specimen showing extensive neoplastic invasion of both right and left lobes of the liver. Note the dome-like appearance of the right lobe of the liver.

obtained at this time, and the diagnosis of cirrhosis of the liver was made.

He was re-admitted two months later with profuse hematemesis from esophageal varices. The lungs were clear. His liver again was felt 3 fingerbreadths below the costal margin. Bleeding persisted despite vigorous treatment. At operation the diagnosis of cirrhosis of the liver was confirmed, and a hepatoma was identified.

The patient expired thirty-six hours after operation. At necropsy the liver weighed 2,400 gm., and measured 29×21×10 cm. (Fig. 2*C*). It was firm and nodular, some nodules measuring up to 5 cm. in diameter. Many nodules and the capsule of Glisson were invaded by whitish gray tumor masses. Approximately 40 per cent of the liver substance was replaced by solitary and confluent nodules. The surface of the liver was fixed to the anterior chest wall and the dome of the right diaphragm by fibrous adhesions. The dome of the right diaphragm was elevated by the liver, but no tumor invasion of the diaphragm was found.

Case II. H. S., a thirty-five year old female, had had a left radical mastectomy six months before admission. Axillary lymph node metastases were present. Operation was followed by roentgen therapy. The patient was asymptomatic until one month before entrance to the hospital. At that time she had what was considered a respiratory infection, with diffuse right chest pain and cough. This responded to medical treatment. The liver edge was felt about two fingerbreadths below the costal margin. Soon thereafter she had severe pain in the low midback radiating down both lower extremities, and roentgenographic examination disclosed extensive metastases to the lumbar spine and pelvis. About six weeks later she was re-admitted in an obviously deteriorated condition, with ascites and moderate jaundice. After the removal of 6,500 cc. of bile stained fluid from the abdomen, a huge nodular right hepatic lobe was felt. Abdominal distress continued, and the patient expired after becoming drowsy, febrile and anuric.

Roentgenographic examination of the chest during her first admission showed the right diaphragm to be 5 cm. higher than the left (Fig. 3*A*). Its lateral aspect was bulging and the right costophrenic sinus was shorter than the left. The lungs were clear. Roentgenkymograms of the diaphragm showed restriction of motion of both the right and left diaphragm (Fig. 3*B*). This was interpreted as indicative of enlarge-

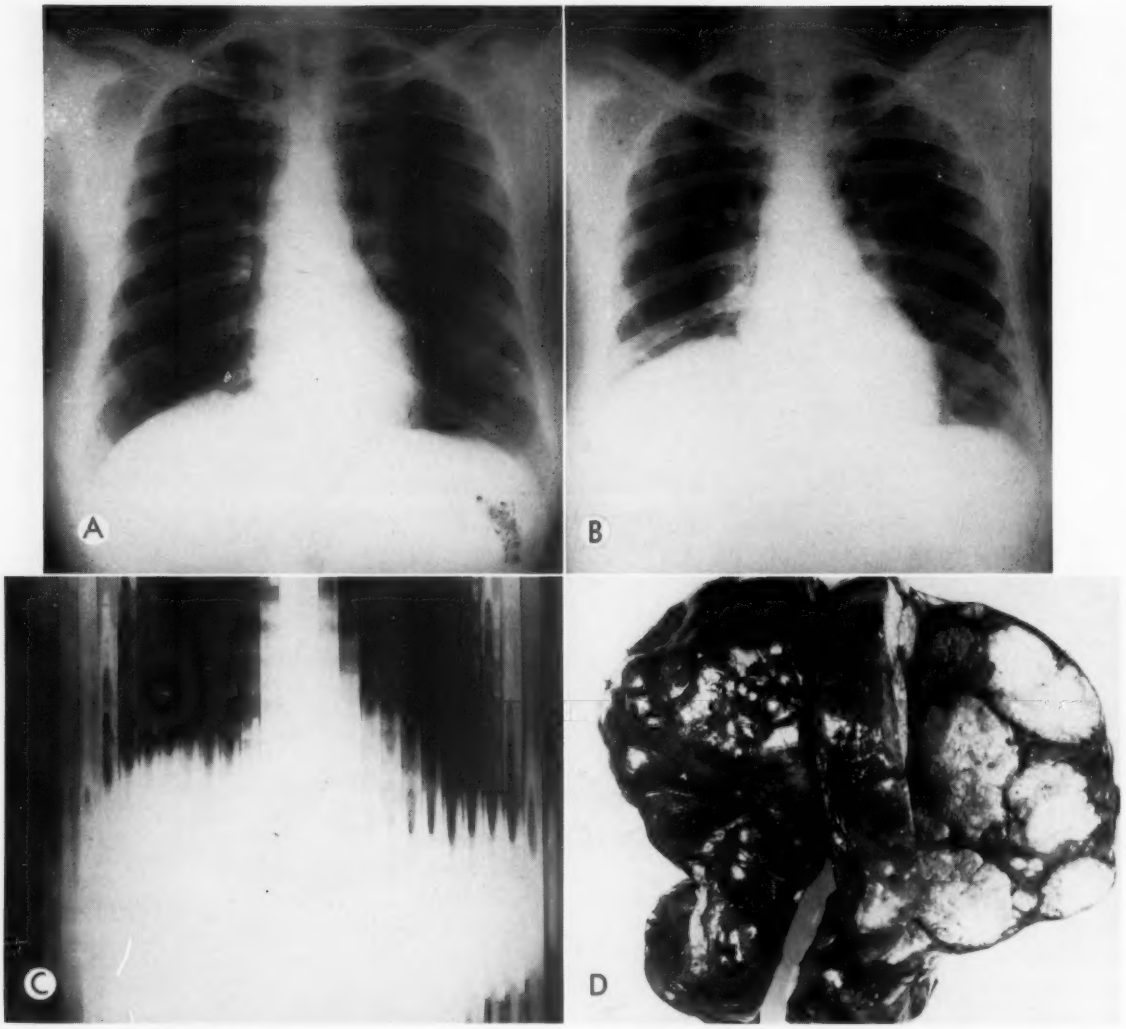

Fig. 4. Case III. (*A*) Teleroentgenogram of the chest showing no gross disturbance in the position of the diaphragm. The lateral aspect of the right diaphragm bulges slightly. (*B*) Teleroentgenogram of the chest made three weeks later. Note the rapid ascent of the right dome of the diaphragm and its bulging appearance. The costophrenic sinus is somewhat shortened. (*C*) Roentgenkymogram shows a marked limitation of motion of the right diaphragm. (*D*) Specimen of liver. Note the extensive metastatic involvement of the liver parenchyma. The capsule of Glisson is relatively intact. The nodular deformity of the dome of the liver is apparent. The primary lesion was a carcinoma of the cecum.

ment of the dome of the liver and possible metastases to the left as well as the right hepatic lobes.

At necropsy the liver weighed 2,600 gm., and was yellow-brown in color, with patches of hemorrhage. The edges were rounded, and umbilication was present in the right lobe. The diaphragm was free of adhesions or tumor. The left lobe of the liver extended to the anterior axillary line on the left side. On section the normal architecture was replaced by confluent yellow-white tumor nodules varying from 2 mm. to 2 cm. in diameter. About 80 per cent of the liver parenchyma had been replaced by tumor (Fig. 3*C*).

Case III. E. H., a forty-four year old woman was admitted to the hospital after having had fever of unknown origin for a period of about three weeks. Slight tenderness was elicited on pressure over the upper abdomen, and the liver edge was felt 3 cm. below the costal arch. The clinical impression was hepatitis or chronic cholecystitis. An intravenous cholangiogram

was normal. A barium enema examination disclosed a polypoid cecal carcinoma. This was confirmed at operation, when massive liver metastases were found. Preoperative roentgenographic examination of the chest showed the right diaphragm to be slightly higher than the left (Fig. 4*A*). Another examination three weeks later (Fig. 4, *B* and *C*) showed a definite increase in the height of the diaphragm, with a bulging configuration and restriction of motion of about 75 per cent. The patient expired after a progressively downhill course.

At necropsy there was extension of hepatic metastatic tumor into the inferior surface of the right diaphragm in the form of small nodules, all less than 0.5 cm. in diameter. The liver weighed 3,200 gm., and measured 30×25×13 cm. (Fig. 4*D*). It was studded with numerous knobby metastases up to 5 cm. in diameter. Some of the larger ones were umbilicated. On section the liver was packed with similar metastases.

DISCUSSION

In differential diagnosis the question as to subhepatic or subphrenic abscess may arise. Aside from the difference in the clinical picture, the presence of pleural effusion is more common with subdiaphragmatic inflammations. Elevation and restriction of motion of the diaphragm because of injury to the phrenic nerve, or by mediastinal tumors compromising this structure, also have to be excluded. Partial eventration of the right diaphragm does not, as a rule, produce the single bulging contour described here, and the movement of the diaphragm is not restricted as much. Complete eventration of the right diaphragm is uncommon, and can be identified better after every other possibility is ruled out. As a rule, such elevation is noted soon after birth, and is not associated with hepato megaly. It should be emphasized that information obtained by this procedure is significant only when positive because it is possible to have considerable metastatic involvement of the liver with no demonstrable reflections in the position or motion of the diaphragm.

SUMMARY

Elevation and impairment of movement of the right diaphragm may be produced by hepatic metastases of sufficient bulk, particularly when the dome of the liver is affected. Sometimes the capsule of Glisson and the diaphragm itself are invaded, which may contribute to these changes. While the association of hepatomegaly with liver metastases is well recognized, the apparent size of the liver as palpated through the abdomen may not correspond with its actual size, especially when the dome of the liver is predominantly involved. Such a change is associated in an appreciable number of patients with a bulging upward convexity of the right diaphragm and restriction of its motion. Pleural or pulmonary reactive changes are infrequent in these patients.

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REFERENCE

1. Epstein, B. S. Roentgen kymography of diaphragm. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1955, *74*, 70–85.

ROTATIONAL CINEFLUOROGRAPHY*

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CINEFLUOROGRAPHIC techniques are capable of rendering information not fully obtainable by conventional roentgenographic methods. Analysis of cinefilm recordings by repeated viewings, using special analyst-type projectors, makes possible an awareness of details which become manifest because of their motion. Admittedly, at present, the limitations of apparatus are such that cinefluorographic techniques are essentially confined to study of small areas. However, such limited studies afford an indication of the potentialities of cinefluorography as equipment is improved to permit study of larger areas.

The usefulness of the motion factor of cinefluorography has been extended in this laboratory by the addition of rotary movement of the subject of the study (dogs) during cinefilming. For this purpose, we have designed a device which rotates the subject in the manner of a rotisserie.

Rotation of a subject during fluoroscopy is an established practice for the determination of spatial relationships of structures. A tri-dimensional impression is obtained during axial rotation of a subject when images closer to the observer are seen to move in a direction opposite to far-sided images. In addition, closer images appear to move faster than those located more deeply within the rotating subject, although actually the rate of rotation is the same. The net effect is more pronounced when the images are rather widely displaced from each other.

Equipment for performing true stereoscopic cinefluorography on either moving or stationary objects by means of dual roentgen-ray tube sources and cameras has been described by several investigators.[1,3,4]

The system devised by Weinberg, Watson and Gramiak[5] employs a stationary single camera with a moving roentgen-ray tube and revolving subject. The film recordings obtained with the latter equipment may be viewed without alteration, taking advantage of the pseudotridimensional effect described above, or individual frames can be matched to provide stereoscopic pairs for dual projection enabling true stereoscopic polaroid viewing.

In our laboratory, the idea of rotary motion of the subject during cinefilming evolved from our efforts to obtain a more complete study of coronary vessels by means of multiple projections and a better appreciation of depth relationships. The anatomic displacement of the right and left coronary arteries is sufficient to create a rather striking illusion of their depth relationships when rotation of the subject is employed during coronary arteriography.

The application of rotational cinefluorography seemed particularly advantageous to our cardiac arrest coronary arteriography procedures.[2] Acetylcholine-induced cardiac arrest immediately followed by catheter thoracic aortography can effect an excellent ten second opacification of the coronary arterial system. The details of investigations on cardiac arrest coronary arteriography are in process of preparation for publication. A ten second coronary opacification permits ample time for a full 180° rotational cinefilming.

The technique of rotational cinefluorography has been adapted by us to a Philips 5 inch image amplifier tube, fitted with a 16 mm. motion picture camera capable of speeds up to 64 frames per second. The 5 inch field of the amplifier tube will include the cardiac shadow of a small dog within a weight range of 15 to 25 pounds. The dog is

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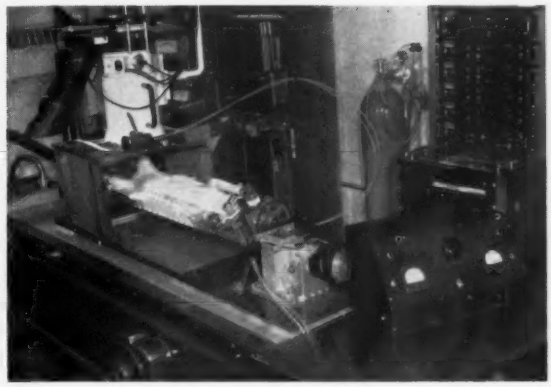

Fig. 1. Dog positioned in crib for rotational cinefluorography. Automatic driving mechanism and variable speed control components in foreground.

secured to a plastic crib-like structure, which is suspended above the roentgenographic table from a metal supporting frame, similar in general design to an ordinary lawn swing frame (Fig. 1 and 2 *A*). For human subjects, the dog crib could be replaced by a brat-board type of holder (Fig. 2 *B*).

The crib or board is adapted to the supporting frame to allow adjustment of the level of the subject, upwards or downwards, in relation to the table top. Elevating screws at either end of the crib are used to obtain a level such that a line through the long axis of the heart corresponds to the axis of the rotating crank shaft. The subject is fluoroscoped under the image tube and rotated to determine the optimal level at which the heart remains within view during the rotation from one lateral position to the other. During the actual filming procedure the viewing screen may be shifted in the usual manner, if necessary, to maintain centering of the heart. The motor driven crank shaft has a variable speed control and a switching mechanism for starting, stopping or reversing the rotation. Variations of tissue thicknesses in lateral as compared with frontal projections in human subjects require compensatory adjustment of roentgenographic exposure factors. A variac filament control device which alters the milliamperage during appropriate phases of the rotation cycle can effect uniformity of film exposures.

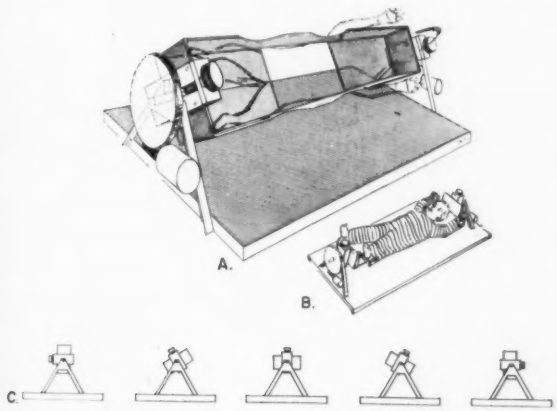

Fig. 2. (*A*) Drawing of crib for rotational cinefluorography in animal studies. (*B*) Drawing of proposed human infant application to rotation equipment. (*C*) End views of equipment in varying phases of 180° rotation cycle.

The apparatus facilitates preliminary positioning of intra-aortic or intracardiac catheters because of the relative ease of obtaining various angles of projection for orientation. With a catheter in position and with the heart properly centered and leveled, injection of opaque medium is made simultaneously with the beginning of rotation and filming. Rotation can be conducted through any degree desired. Figure 3 illustrates the multiplicity of projections obtainable with rotational cinefluorography during dog coronary arterial opacification using the technique of acetylcholine-induced cardiac arrest.

Cinefilms obtained by this technique create an illusion of depth perception, especially noticeable in coronary opacification studies. Larger than usual amounts of medium may be required for angiocardiography to visualize cardiac chambers through most of the rotation cycle. Visualization throughout the entire cycle is, of course, also dependent upon speed of rotation and the use of relatively higher rates of cinefilming. To a limited extent, we have applied rotational cinefluorography to our angiocardiographic studies in dogs, although rotation techniques would appear to have a rather restricted value in angiocardiography.

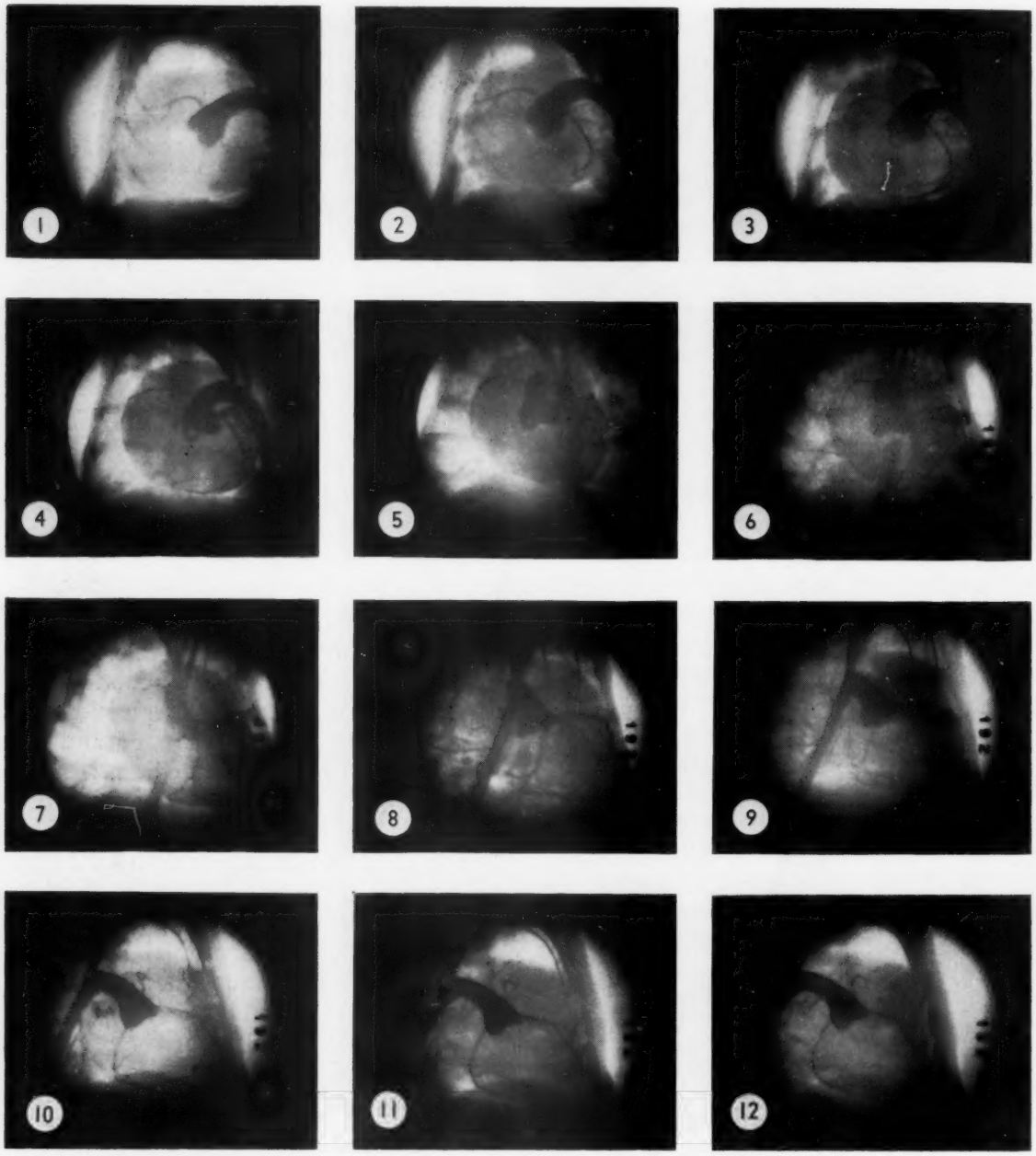

FIG. 3. Selected frames from film of rotational cinefluorographic study in dog, employing single opaque injection during acetylcholine-induced cardiac arrest coronary arteriography.

The rotational device has also been used with a rapid serial film changer during cardiac arrest coronary arteriography in dogs. With this combination, we have succeeded in obtaining roentgenograms of good quality through a full 180° of rotation. The multiple projections shown in Figure 4 were made during rapid serial filming and rotation. Prolonged coronary arterial opacification in this case was accomplished by means of combined cardiac arrest and aortic balloon occlusion.

We have recognized the teaching value of the rotational technique as related to cardiac chamber, coronary arterial and intrathoracic great vessel orientation.

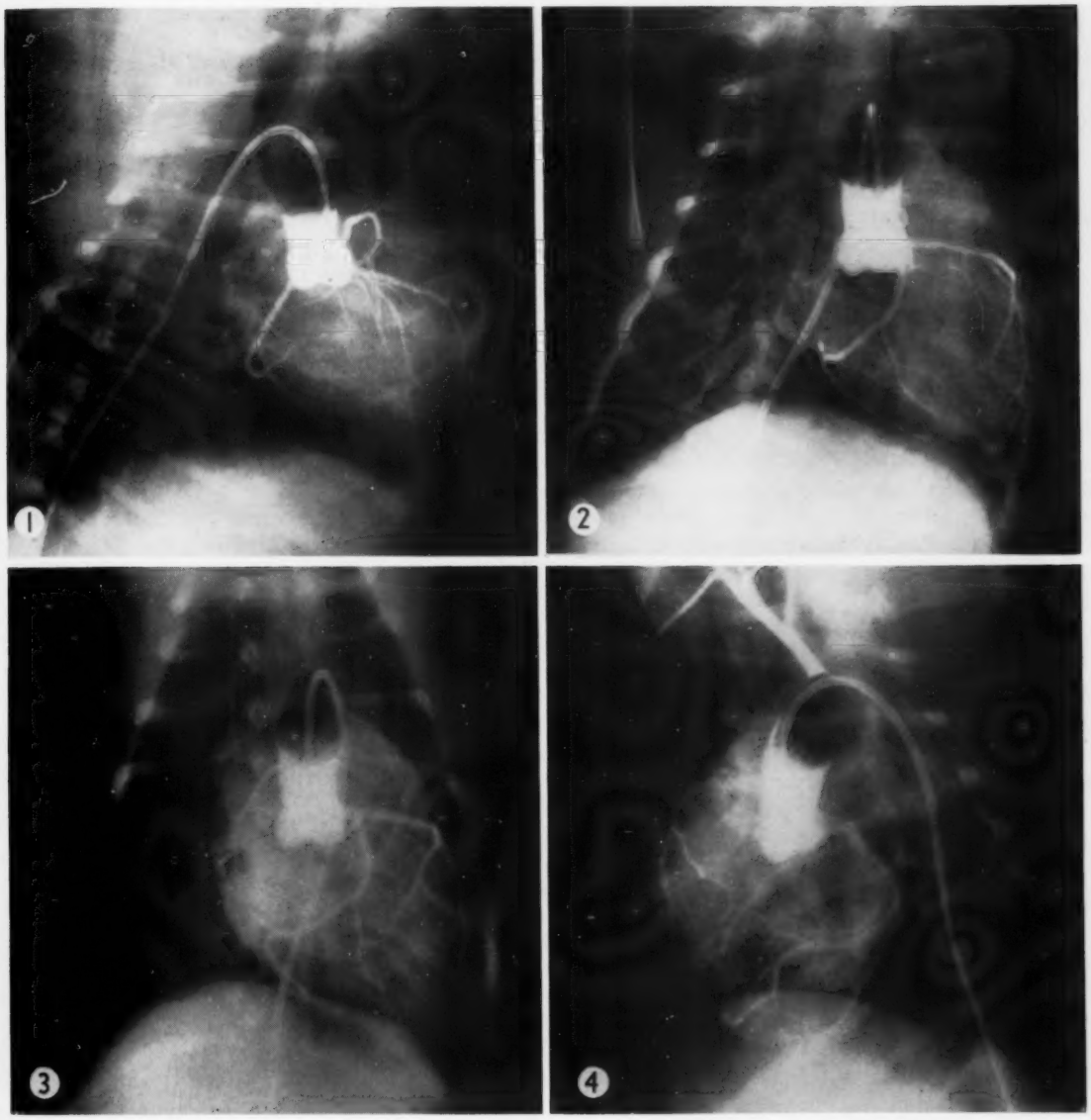

Fig. 4. Selected roentgenograms in varying phases of rotation during dog coronary arteriography, employing single opaque injection and utilizing rotation equipment with rapid serial film changer. Acetylcholine-induced cardiac arrest and aortic balloon occlusion.

At present, there are definite limitations upon the clinical application of cinefluorography imposed by presently available equipment and films. The research possibilities of rotational cinefluorography at present outweigh the clinical applications. As techniques and equipment improve to permit study of larger areas, the clinical potentialities will almost certainly broaden. Applications to various anatomic areas, particularly the human heart, may offer far-reaching possibilities for improvement in roentgen diagnoses.

SUMMARY

1. A procedure for axial rotation of experimental animals and human subjects during cinefluorography is described.

2. A motor-driven plastic cradle to effect axial rotation of animals during cinefilming has been devised.

3. The principal advantages of rotational cinefluorography, *i.e.*, multiplicity of projections and a pseudotridimensional effect, are discussed.

4. Application of the procedure to coronary arteriography with acetylcholine-induced cardiac arrest in experimental animals (dogs) is illustrated.

5. The potential clinical applications of this technique of rotational cinefluorography are considered.

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REFERENCES

1. Janker, R. Zur Frage der Röntgenstereoskopie. *Fortschr. a. d. Geb. d. Röntgenstrahlen ver. m. Röntgenpraxis*, 1949, *71*, 339–344.
2. Lehman, J. S., Boyer, R. A., and Winter, F. S. Coronary arteriography. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1959, *81*, 749–763.
3. Lupacciolu, G., d'Amico, M., Iacobini, M. Romano, L., and Tedeschi, A. L'analisi stereoscopica nella diagnostica radiologica; progressi di tecnica e proiezione diretta nello schermo dell'immagine tridimensionale. *Riforma med.*, 1956, *70*, 349–359.
4. Rushmer, R. F., Ellis, R. M., and Nash, A. A. Stereo-cinefluorography. *Radiology*, 1955, *64*, 191–196.
5. Weinberg, S. A., Watson, J. S., Jr., and Gramiak, R. Perfect stereoscopic cinefluorography. *General Electric X-Ray News*, 1953, *25*, 7.

CONGENITAL DEFICIENCIES IN THE PARIETAL PERICARDIUM*

A REVIEW WITH 2 NEW CASES INCLUDING SUCCESSFUL DIAGNOSIS BY PLAIN ROENTGENOGRAPHY

By KENT ELLIS, M.D., NORMAN E. LEEDS, M.D., *and* AARON HIMMELSTEIN, M.D.
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CONGENITAL pericardial deficiency, perhaps first described by M. Realdus Columbus[21] in 1559, is a rare anomaly which has seldom been diagnosed prior to death. In those few cases the diagnosis was made incidentally at operation or following a left pneumothorax induced as a treatment for pulmonary tuberculosis or in the investigation of lung cysts.

This report records the first case of congenital absence of the left pericardium in which the diagnosis was suggested on the basis of plain roentgenograms of the chest, and subsequently confirmed by diagnostic pneumothorax. Another case diagnosed at operation is also presented.

Fanfani and de Biase[30] in 1954 reported a case of congenital pericardial defect and reviewed the literature on this subject, finding a total of 93 cases. If the cases of Southworth and Stevenson,[75] Meckel,[49] Walter,[83] Kerley,[41] and Venturini and Pesci[79] are added to this list (and one case is dropped because of the apparent identity of the cases reported by Ménière[50] and Breschet[12]), the 2 cases presented here represent the ninety-eighth and ninety-ninth reported cases.

REPORT OF CASES

CASE 1. T.P., P.H. Unit No. 816474. This forty-two year old married Puerto Rican female dress-maker was first seen in 1946 as an out patient with complaints of weakness, fatigue and sleeplessness of at least eight years' duration, with recent onset of chest and neck pain. Physical examination was unremarkable except for a loud inconstant diastolic murmur at the sternal border in the left third intercostal space and variable systolic murmurs.

No family history of congenital abnormality was elicited. The patient's only pregnancy had resulted in a female infant who died at forty-five days of age of unknown causes. The patient claimed always to have been tired and anorexic. At about the age of ten she had had multiple joint pains and fever associated with dyspnea. Rapid walking and stair climbing resulted in dyspnea and chest discomfort. Cervical spine roentgenograms revealed a congenital abnormality of the vertebrae with incomplete segmentation at the C1–C2 and perhaps at the C7–T1 levels. Chest roentgenograms showed an unusual cardiac silhouette (Fig. 1). A small oval bleb could be noted in the lingula, apparently related to the left heart border by pleuropericardial adhesions.

No specific diagnosis could be made and the patient was followed intermittently for bouts of left anterior chest pain.

On January 13, 1950 she was admitted to the Presbyterian Hospital with left chest pain and dyspnea. Severe anterior chest pain radiating to the neck had begun suddenly one month previously and had continued in reduced intensity until hospitalization.

On physical examination this small well developed woman had a blood pressure of 125/80, a pulse rate of 80/min., and signs of a pneumothorax on the left. A Grade II apical systolic murmur was present as well as a Grade III systolic murmur heard best at the left cardiac border in the fourth left intercostal space. An enlarged nodular thyroid gland was palpated.

Roentgen examination of the chest showed a left hydropneumothorax with gas extending into a space between the right cardiac border and the lower right lung (Fig. 2 and 3). One of the considerations at this time was the possibility of air being present in the pericardium.

The patient was treated with bed rest, and an extensive laboratory work-up was unrevealing. The electrocardiogram was interpreted as show-

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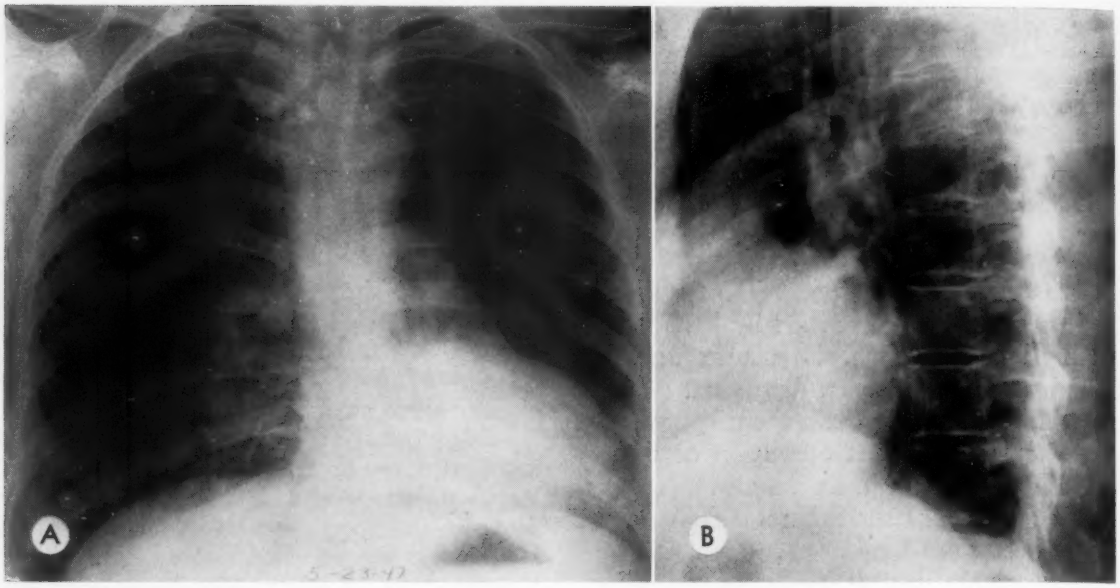

FIG. 1. Case 1. (*A*) Posteroanterior chest roentgenogram taken May 23, 1947 shows a shift of the heart toward the left and an elongated unusual appearing cardiac silhouette. The pulmonary artery segment is prominent and a radiolucent cleft separates the pulmonary artery from the aortic knob. (*B*) Left lateral roentgenogram of chest shows the cardiac configuration and the distinctness of outline of the main pulmonary artery.

ing sinus bradycardia and right axis deviation. Gastric aspirations upon culture ultimately yielded no acid fast organisms.

Because of persistence of the pneumothorax and a suggestion of lung cysts on several chest roentgenograms, on February 9, 1950 a left

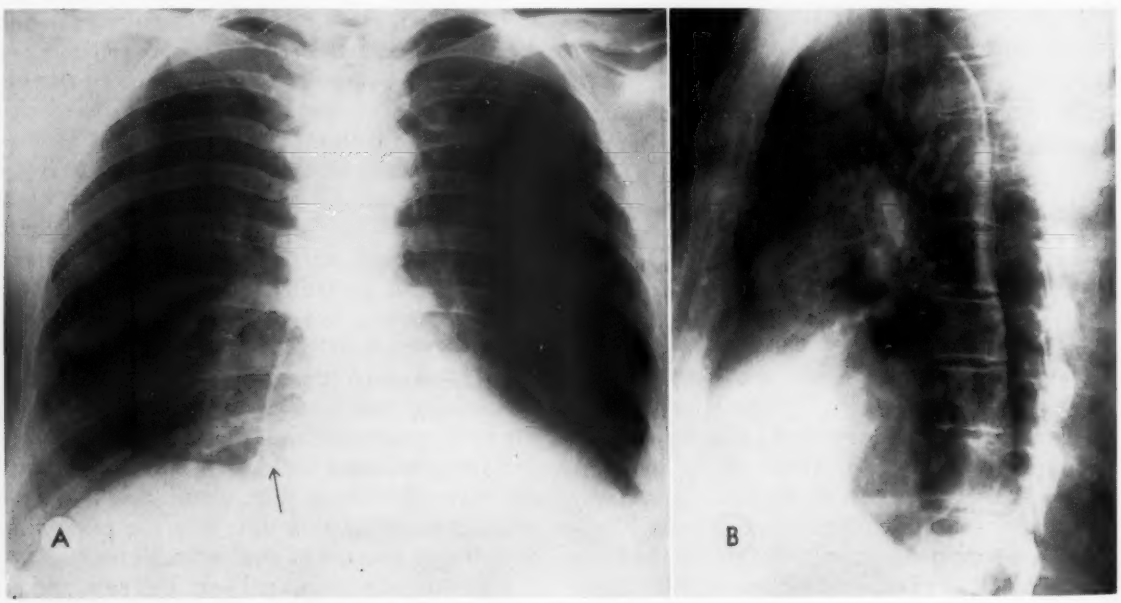

FIG. 2. Case 1. (*A*) Posteroanterior chest roentgenogram taken January 17, 1950 shows a spontaneous left pneumothorax. The right pericardium and adjacent pleura are seen as a linear density between right lung and gas within the pericardium. (*B*) Left lateral chest roentgenogram. Note pneumothorax and again the unusually clear demonstration of the main pulmonary artery.

Fig. 3. Case 1. Frontal laminagram with patient supine taken on January 25, 1950 showing gas separating the heart from the diaphragm and the right pericardium following spontaneous left pneumothorax.

exploratory thoracotomy was performed. *The left side of the pericardium was absent.* A thin fibrinous exudate was noted on the cardiac surface. No fissures were found in the left lung. A multiloculated 3 cm. bleb on the medial surface of the lingula was resected.

The patient recovered from the pneumothorax following operation and has had no recurrences.

In 1952 at the Francis Delafield Hospital in New York City the patient had a total thyroidectomy and a left radical neck dissection for papillary adenocarcinoma of the thyroid and lymph node metastases and has had no evidence of recurrence since.

In September, 1957 on physical examination a Grade III rough systolic murmur was heard in the pulmonary area as well as a Grade II apical systolic murmur. The electrocardiogram showed sinus bradycardia and low voltage, especially in the right precordial leads.

Except for mild 2–3 flight dyspnea and some intermittent left anterior chest pain, more marked at night or with exertion, the patient has remained well.

Case II. O.G., P.H. Unit No. 1316774. This twenty-six year old single white man presented to the Presbyterian Hospital in March, 1957 with a chief complaint of left precordial pain intermittently experienced for about six years. The pain was often associated with a sensation of tightness in the chest, soreness in the left shoulder, and palpitations. It varied somewhat but was usually felt as a "sharp" pain in the left precordium, sometimes radiating to the back, and lasting from ten seconds to thirty minutes. Over the years the episodes of pain seemed to be increasing in frequency. Although more likely to occur after strenuous exercise or overeating, the pain also occurred while resting in bed, and, in fact, was often relieved by mild exercise. On some days the patient had no pain, while on other days there would be several episodes. He also had dyspnea after moderate to severe exertion.

The patient was born in Yugoslavia and migrated to New York in 1951, having spent some time in a concentration camp. He was always smaller and more frail than his six siblings. On questioning he did not know of any congenital or hereditary diseases in his family. Although frail as a child, he had not experienced joint symptoms or chorea to suggest earlier rheumatic fever.

The positive physical findings of this well developed and well nourished man included a prominent precordial pulse maximal in the sixth interspace at the anterior axillary line, a pulmonary second sound which was much louder than the aortic second sound, and a Grade II–III pulmonary systolic murmur heard by many observers. The initial clinical diagnosis was congenital heart disease—pulmonic stenosis.

Roentgenographic examination of the chest demonstrated an unusual cardiac configuration (Fig. 4). An electrocardiogram showed sinus bradycardia, probably due to incomplete right bundle branch block, and an otherwise abnormal but nonspecific record.

On September 17, 1957 a right heart catheterization (including catheterization of the pulmonary artery) revealed no abnormality. On October 30, 1957 a technically adequate angiocardiogram showed no abnormality except for the unusual cardiac silhouette (Fig. 8).

Since these examinations were unrevealing and since the plain roentgenograms of the chest in combination with the clinical findings suggested to us that the patient might have an absent left pericardium, a diagnostic pneumothorax was recommended.

Multiple roentgenograms of the chest were made on July 9 and 10, 1958 after introduction

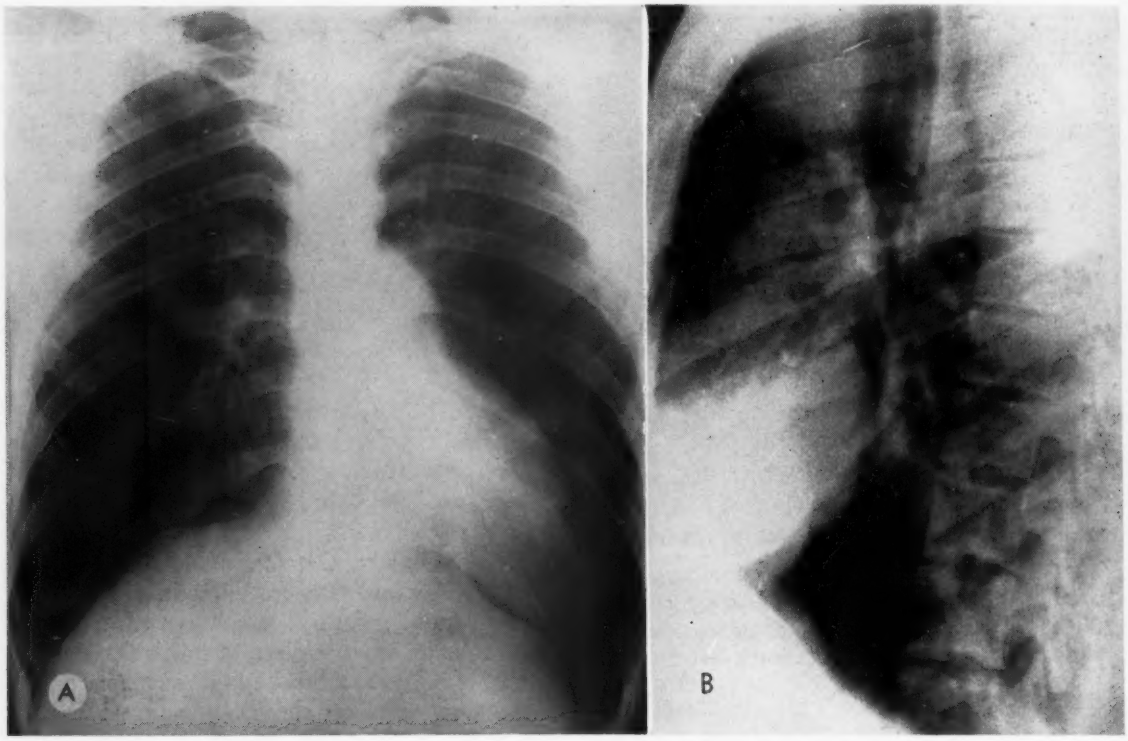

FIG. 4. Case II. (*A*) Posteroanterior roentgenogram of the chest showing shift of heart to left and three convexities along the elongated left heart border, the aortic knob, the pulmonary artery segment and the ventricular segment. Note the similarity to Case I (Fig. 1, *A* and *B*). (*B*) Lateral roentgenogram of chest.

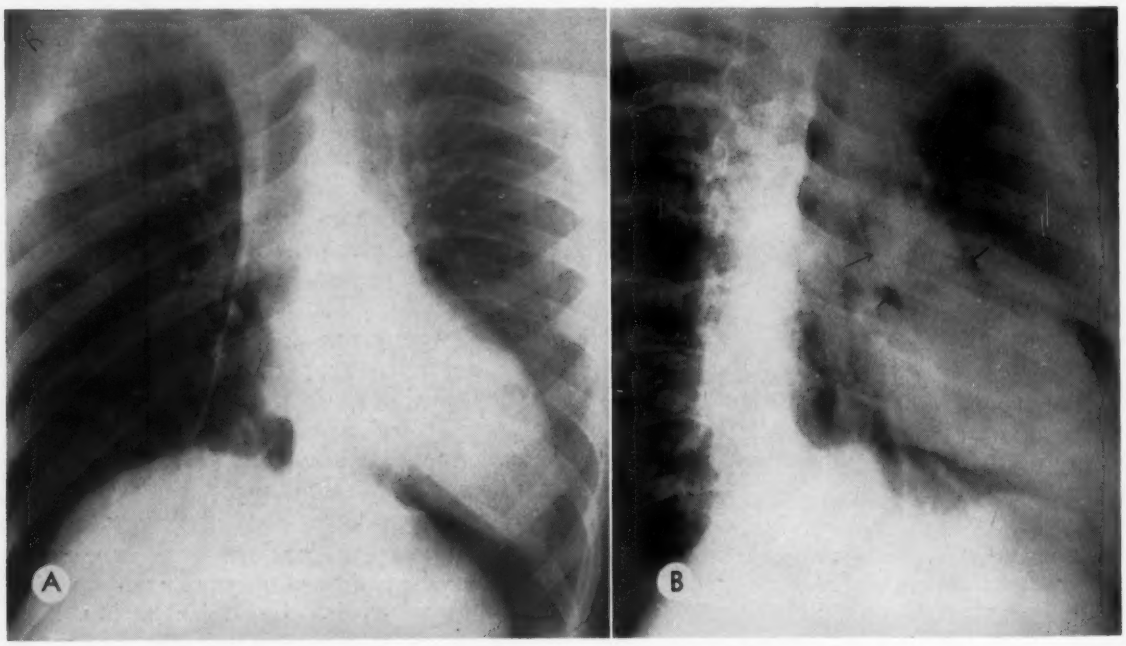

FIG. 5. Case II. (*A*) Right posterior oblique roentgenogram of the chest taken with a horizontal beam and the left side down following introduction of 500 cc. of air into left pleural space. The gas clearly separates the heart from the diaphragm. As in Case I (Fig. 2, *A* and *B*) the right pericardium and overlying pleura are seen as a linear density contrasted between gas in the right lung and gas in the pericardium. (*B*) Left posterior oblique roentgenogram taken with a horizontal beam and the left side down following left pneumothorax. Gas surrounds the ascending aorta within the pericardium.

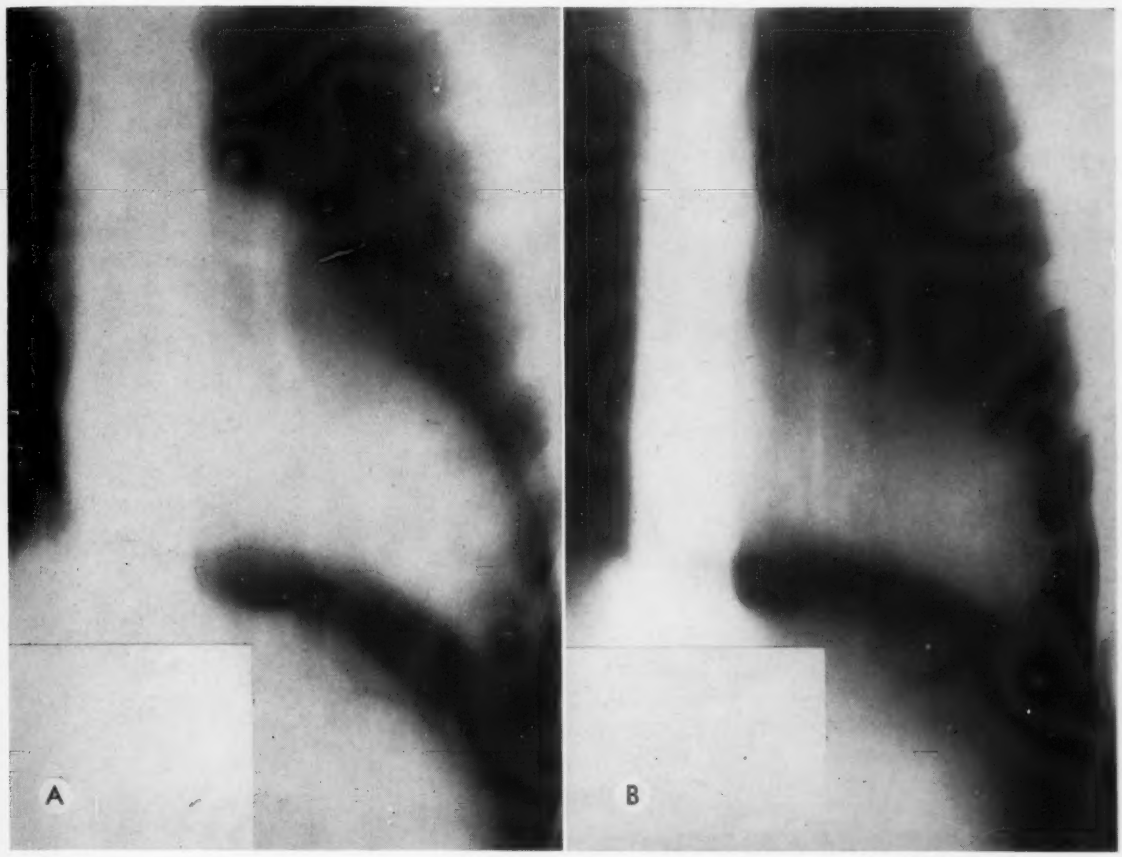

Fig. 6. Case 11. (*A*) Frontal laminagram with the patient supine taken following introduction of 500 cc. of air into the left pleural space. The gas clearly separates the heart from the diaphragm dome. (*B*) Identical projection with less radiation exposure.

of 500 cc. of air into the left pleural space by Dr. Julius H. Jacobson. These roentgenograms showed gas in the pericardium—a finding which we believe to be diagnostic of a defect in the left side of the pericardium (Fig. 5, 6 and 7).

At this time the patient gave the additional information that for years he had slept in the prone position because he had had frequent episodes of chest pain when lying on his back or on his left side, less pain when lying on the right side and was usually comfortable when lying prone.

Although we cannot be certain, the circumstantial evidence suggests that the patient's chest pain may be related to the pericardial abnormality.

Fig. 7. Case 11. Lateral roentgenogram of the chest taken with the patient supine following introduction of 500 cc. of air into the left pleural space. In the absence of the left pericardium, the heart falls away from the anterior chest wall and diaphragm.

EMBRYOLOGY AND CLASSIFICATION OF PERICARDIAL DEFECTS

According to Patten[59] the first indication of the partitioning off of the pericardial cavity from the rest of the coelom is given

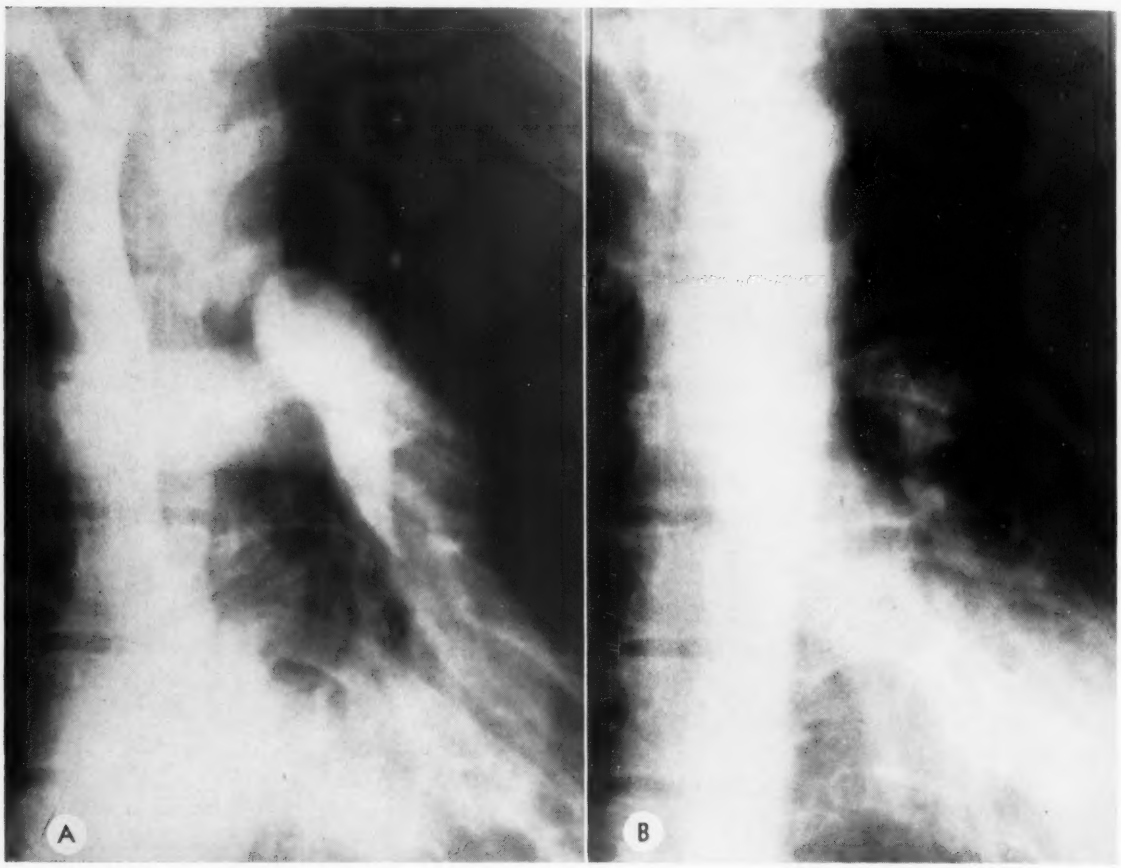

FIG. 8 Case II. (*A*) Frontal angiocardiogram showing position and contour of opacified main pulmonary arteries. (*B*) Same projection four seconds later showing left sided position of ascending aorta in relation to spine but no change in relative position of descending aorta.

by the formation of the transverse septum, a transversely placed mass of mesoderm situated just caudad to the heart and extending dorsad from the ventral body wall. The developmental separation of the pericardial and pleural cavities is brought about by the growth of additional folds which become associated with the transverse septum. These folds arise on either side from the dorsolateral body walls where the ducts of Cuvier, as they swing around to enter the sinus venosus of the heart, cause the body walls to bulge into the coelomic cavity. On either side the fold extending cephalad from this primary elevation about the duct of Cuvier is called the pleuropericardial fold. These folds grow cephalad and mesiad, their caudal margins first being continuous with the dorsal margin of the transverse septum. When their cephalic borders meet and fuse with each other and with the mediastinum, they complete separation of the pericardial cavity from the rest of the coelom (the pleural cavities).

Congenital pericardial defects result from incomplete development of either the transverse septum or of the pleuropericardial folds. The great majority of these pericardial defects (66 of 85 described defects) are on the left side, perhaps as suggested by Perna[61] due to premature atrophy of the left duct of Cuvier. The right duct of Cuvier normally persists as the superior vena cava, which tends to insure closure of the right pleuropericardial foramen. Conversely, the left duct of Cuvier normally atrophies to form part of the left superior

TABLE I

CLASSIFICATION OF CONGENITAL DEFECTS IN THE PERICARDIUM

(After Fanfani and de Biase[30] and excluding ectopia cordis and pericardial diverticula)

No. of Cases		
72		A. *Deficiencies in the development of the pleuropericardium (pericardium and adjacent pleura)*
66		1. Left side
	18	(a) Foramen type defects or partial defects 2, 11, 23, 31, 40 (Cases 1 and 2), 48, 49, 51 (Case 1), 56, 57, 65, 66, 67 (Case 1), 69, 72, 76 (Case 1), 79
	48	(b) Large or complete defects with common pericardial and left pleural cavity 4 (Case 1), 5, 6, 9, 12 (same as 50), 13, 16, 17, 18, 19 (Case 1, 2, and 3), 22, 27 29, 30, 34, 37, 38 (Case 1 and 3), 42, 43, 44, 51 (Case 2 and 3), 53, 54, 58 (Case 1), 60, 61, 62 (Case 1 and 2), 63, 64 (Case 1 and 2), 67 (Case 2), 68, 70, 71, 73, 75, 81, 83, 84, 86, 87, and the 2 cases in this report
3		2. Right side
	2	(a) Foramen type defects 33, 41
	1	(b) Complete defects 28
3		3. Both sides (including foramen type and complete defects) 7, 20, 67 (Case 3)
3		B. *Incomplete formation of the pericardium with normal formation of the overlying parietal pleura* 8, 76 (Case 2), 77
10		C. *Defects in the diaphragmatic portion of the pericardium (transverse septum)* 24, 32, 38 (Case 2), 39 (Case 1 and 2), 46, 47 (Case 1 and 2), 55, 74
14		D. *Unclassified (insufficient data)* 3, 4, (? Case 2), 14, 15, 21, 26, 35, 36, 45, 58 (Case 2), 78, 80, 82, 85
99	Total	

Note: The reported cases in the literature are listed so as to correspond with the reference numbers at the end of this article.

intercostal vein and a remnant which lies in the vestigial fold of Marshall. As mentioned, premature atrophy of the left duct of Cuvier might result in an incomplete left pleuropericardial membrane (a left pericardial defect). While the precise mechanism involved is debated, it is generally agreed that the patent left pericardium results from a disturbance in the development of the left pleuropericardial membrane.[40,48,61,64,67,69,76]

The preponderance of these defects in males—73 per cent (59 of 81 cases in which the sex is stated)—is unexplained.

Omitting from consideration the more severe and more primitive ectopia cordis defects as well as pericardial diverticula, Fanfani and de Biase[30] extended the work of Moore[52] and devised a classification of pericardial defects. Utilizing a modification of this classification and drawing largely on the excellent papers of Fanfani and de Biase[30] and Southworth and Stevenson,[75] Table 1 was constructed. In this table we have classified the cases reported with the exception of 14 cases about which there are insufficient data. The validity of a few[14,21,34,36,44,45,77,78,80,85] of these cases has been disputed by Perna[61] and others.[75]

Our primary concern is with the left sided pericardial deficiencies which, as mentioned, include the great majority of defects. These left sided defects vary from a small hole in the pericardium with smooth edges overlying the left aspect of the main pulmonary artery to complete absence of the left pericardium. Somewhat arbitrarily the left sided defects can be divided into two groups: (1) In 48 of the 66 cases the defect was considered to be complete so that the left pleural space and the peri-

cardial cavity constituted one cavity, the cardiac mass not being constrained by the left pericardium. (2) In the other 18 cases the left pericardial defect was smaller, less than complete, and considered a foramen, so that the heart despite the defect was compelled to reside in the pericardial cavity.

CLINICAL FEATURES

A number of functions have been claimed for the pericardium including the protection of the heart from overdistention in diastole, the maintenance of the heart in optimal functional position, the isolation of the heart from the noxious influence of pulmonary disease and, conversely, the separation of the lung from the trauma of the beating heart.

Although experimental surgery performed in the investigation of the function of the pericardium has yielded somewhat variable results, recent investigators[10,53] suggest that the heart functions normally despite a surgically absent pericardium. Southworth and Stevenson's[75] conclusion that, in general, individuals with congenital pericardial deficiency have a near normal life span without disability due to the anomaly *per se* is strong support for the view that the pericardium is not essential. Cardiac enlargement has been found at necropsy in about 50 per cent of such patients, though an explanation in terms of more prosaic cardiac disease is commonly but apparently not always available. Clinically the characteristic left sided position of the heart and its strong apical impulse would tend to give the impression of cardiac enlargement both on physical examination and roentgenographically even when no actual enlargement is present.

Adverse influence of pulmonary and pleural disease, especially infection, upon cardiac function in the absence of the pericardium has been considered important by several authors.[1,75] Southworth and Stevenson[75] pointed out that pneumonia had caused death in almost 20 per cent of the cases, while several other cases had an acute pleuropericarditis at necropsy. Pulmonary infection may be responsible for the adhesions which have been found in about 75 per cent of the cases, between the epicardium and the left lung, the diaphragm or the pericardial remnant. In some instances the direct trauma inflicted by the beating heart upon the adjacent lung may cause a local inflammatory response and resulting adhesions.

The variable cardiac murmurs present in our 2 cases are not well explained, and at this time we cannot absolutely exclude other causes for these murmurs. Nevertheless, it is possible that these cardiac murmurs may be the consequence of turbulence, set up by varying mechanical deformations at the base of an unusually mobile heart. Although unexplained cardiac murmurs have not been featured in the reported cases, only a very few of these individuals were under careful clinical scrutiny prior to death.

Not more than 3 or 4 patients have been described with chronic chest symptoms which could conceivably be attributed to pericardial deficiency.[53,75] Both our patients, however, had unexplained chest pain possibly related to the pericardial defect. The relationship seems particularly reasonable in Case II, in which the incidence of chest pain could be greatly modified by changes in posture. Chest pain could result from increased stress on the anchoring structures of the cardiac base occasioned by the absence of the stabilizing left pericardium. Variable and excessive tension on the commonly present cardiopleural adhesions might also produce chest pain.

A spectacular consequence of the anomaly has been death resulting from herniation of the heart through a left pericardial foramen. Boxall[11] reported a twenty-eight year old woman who died three days post partum with the heart herniated through a pericardial defect and partially strangulated. Thirty hours before death dyspnea, collapse and a precordial systolic murmur had appeared. Post partum intrathoracic pressure alterations were held responsible for the acute mishap. Sunderland and Wright-Smith[76] describe an apparently

healthy two year old boy who collapsed and died fourteen hours after onset of acute distress. At necropsy, the heart was found to be herniated through a left pericardial foramen. Presumably, cardiac strangulation would not occur in the presence of a completely absent left pericardium as in the 2 cases reported in this paper.

Associated congenital anomalies have been described in at least 11 of 18 cases with left pericardial foramen and in 10 of 48 cases with complete absence of the left pericardium. Although these anomalies range widely in type and severity, they have chiefly involved the heart, the lung or the pleural or peritoneal cavities. Of particular interest has been an associated bronchial cyst in 2 cases[41,69] and an enterogenous thoracic cyst in another.[79]

Pericardial defects have been observed in dogs and a number of other mammals.[52] In one case an orangutan died as a consequence of herniation of the heart through a left sided defect.[25]

Abbott[1] predicted that the clinical diagnosis of congenital pericardial defect of the foramen or partial type was probably impossible. She suggested that the diagnosis might be suspected on clinical grounds in cases with complete absence of the left side of the pericardium. The findings which might lead to the diagnosis were considered to be an unexplained shift of the heart to the left without tracheal deviation in the neck,[75] unexplained cardiac enlargement and a postulated abnormal mobility of the heart.

ROENTGEN FINDINGS

1. Plain Roentgenography. Chest roentgenograms have been described in only 3 cases of foramen-type defect. A lung cyst resided in the partial defect in the case of Rusby and Sellors,[69] which therefore cannot be considered typical. The roentgenogram published in the case of Venturini and Pesci[79] shows a normal appearing heart, while the film in Dahl's[23] case of probable partial defect shows a complicating therapeutic pneumothorax and a grossly normal heart. In general, small defects or foramina in the left pericardium would not be expected to produce specific abnormality on plain roentgenograms of the chest unless either heart or lung had herniated through the defect. In addition to the 2 cases already mentioned in which death resulted from herniation of the heart through a foramen, 2 other cases are on record in which the left atrial appendage projected through a small defect.[40,57] Chest roentgenograms in such instances might show a mediastinal mass or deformity, but no such roentgenograms have yet been described to our knowledge.

Similarly, few chest roentgenograms have previously been described or published in cases of complete left sided pericardial deficiency. The roentgenograms reported in Ladd's[42] case show association with a large left diaphragmatic hernia. The appearance in the roentgenogram of Moore and Shumacker's[53] case has a superficial resemblance to that of our cases but is complicated by severe tricuspid insufficiency and right heart enlargement. In Shafiroff's[73] case the published roentgenogram was taken post mortem and after vascular injection in a newborn infant and is not representative of the uncomplicated cardiac configuration. In Kadin's[38] Case 1 and III the chest roentgenograms are not published but are described only as showing moderate and marked cardiac enlargement, respectively.

Both of the cases described in this report are considered to be examples of complete left sided pericardial defect. The common features noted on the chest roentgenograms are: (a) a shift of the heart to the left and (b) an unusual cardiac silhouette in the frontal projection. The left heart border is flattened as the heart stretches out over the left diaphragm dome. Three convexities are seen along the left heart border: the aortic knob; a long, prominent, and sharply demarcated pulmonary artery segment; and a distinct left ventricular segment (Fig. 1 and 4).

These findings seem to be a reasonable consequence of absence of the left pericardium and the resulting more intimate con-

tact between the left lung and the heart and great vessels.

2. Diagnostic Pneumothorax. In 1868, Powell[65] reported the death of a patient with spontaneous pneumothorax and pulmonary tuberculosis who at necropsy had a large defect in the left pericardium. Of course, no roentgenographic examination was performed. In 1937, Dahl[23] identified gas in the pericardium associated with a left therapeutic pneumothorax for tuberculosis and made the diagnosis of congenital pericardial defect. Rusby and Sellors[69] noted gas about the heart following a diagnostic left pneumothorax for lung mass (cyst), but its significance was not appreciated until after a small left pericardial defect had been found at operation. Kerley[41] mentions a case of congenital pericardial defect in which the diagnosis was implied after noting gas in the pericardium following a diagnostic right pneumothorax done in the investigation of a congenital lung cyst.

Our Case I is the second reported case of pericardial defect associated with spontaneous pneumothorax. Since the ruptured bleb in this case was probably on the cardiac surface of the lingula, one cannot help but wonder if such an accident may not possibly be related to direct lung trauma by the heart in the absence of the left pericardium. In this case while the possibility was considered that the pericardial gas was in the pericardium, the diagnosis of congenital pericardial defect was not seriously entertained prior to operative demonstration of the defect.

In our Case II the diagnosis of congenital left pericardial deficiency was suggested on the basis of the appearance of the plain chest roentgenograms and in the absence of specific abnormality on cardiac catheterization and angiocardiography. A diagnostic pneumothorax successfully substantiated the diagnosis.

A pneumothorax may not always yield diagnostic information, since, in some cases of deficiency in the left pericardium, adhesions might prevent accumulation of gas over the right surface of the heart. A perusal of the literature, however, indicates that such cases may be expected to be unusual. In instances of small defects, gas may enter the pericardial space with difficulty, depending upon gravity effects and the presence of adhesions. In a few cases such as those with bilateral pleuropericardial defects[7,20,67 (Case 3)] or, as in the case of Southworth and Stephenson,[75] those with anterior mediastinal communications between the pleural cavities, diagnostic left pneumothorax might be expected to show gas in both pleural spaces.

In general, pericardial defects large enough to give the type of cardiac configuration demonstrated in the 2 cases presented can be expected to show gas in the pericardium if roentgenograms in the proper projections are obtained. For example, in Case II even several hours after introduction of 500 cc. of air into the left pleural space and despite many positional changes designed to permit filling of the pericardium prior to roentgenography, gas to the right of the heart was not obvious in the erect posteroanterior and lateral and in the decubitus lateral roentgenograms of the chest. Superimposition of the right cardiac border on the spine may have been partly responsible for this. The most impressive roentgenographic demonstration was made utilizing a horizontal beam, with the patient lying on the left side in a slightly right posterior oblique position in relation to the film (Fig. 5). This projection is considered optimal in that the right heart border is not superimposed on the spine, and yet gas in the left pleural space with the help of gravity has an opportunity to penetrate fully the pericardial cavity.

Other studies of special interest include anteriorposterior supine Bucky roentgenograms and laminagrams, which demonstrate clearly gas separating the heart from the left diaphragm dome (Fig. 3 and 6). A supine lateral roentgenogram utilizing a horizontally directed beam reveals the ability of the heart to fall away from the anterior chest wall and diaphragm in the absence of the left pericardium (Fig. 7). In at least one reported case, the lung was interposed

between the heart and the anterior chest wall.[84]

3. Cardiac Fluoroscopy. Cardiac fluoroscopy is not expected to provide much help in the positive diagnosis of pericardial deficiency. It might be useful in optimally positioning some patients for roentgenography after a diagnostic pneumothorax. An experienced fluoroscopist might note the unusual cardiac silhouette or abnormal mobility of the heart. Our Case 11, like the patient of Southworth and Stevenson,[75] exhibited prominent cardiac pulsation at fluoroscopy though in the absence of necropsy we could not exclude some additional cardiac pathology.

4. Angiocardiography. Angiocardiography helps rule out other cardiac abnormalities and accentuates the unusual cardiac configuration (Fig. 8). It has, of course, little positive value in making the diagnosis.

DIFFERENTIAL DIAGNOSIS

Traumatic, surgical, neoplastic and inflammatory processes may produce pericardial defects, but these mechanisms can ordinarily be suspected on the basis of clinical history.

The appearance of the heart on plain chest roentgenograms, which has been demonstrated by the 2 cases reported, is not necessarily diagnostic of congenital absence of the left side of the pericardium. Nevertheless, when a cardiac silhouette of this type is observed, the possibility of congenital absence of the left pericardium should be considered. Then, depending upon the individual clinical situation, a diagnostic left pneumothorax may be worth performing to confirm the diagnosis.

SUMMARY

Two cases of congenital deficiency of the left side of the pericardium are presented. Experience with the first case led to the correct diagnosis of the second case on the basis of the plain chest roentgenograms.*

The clinical findings in 97 previously recorded cases of congenital pericardial deficiency are reviewed from the point of view of the radiologist. Complete absence of the left side of the pericardium, as in the 2 cases presented here, is the most common type of pericardial defect, being present in at least 48 of the reported cases.

In complete absence of the left side of the pericardium, an unusual though apparently typical cardiac silhouette may be present on the plain chest roentgenograms. The heart is shifted toward the left, and the flattened left heart border has an unusually long and well defined pulmonary artery segment. A technique for confirming the diagnosis by pneumothorax is demonstrated.

* A case reported by G. G. Rowe and L. W. Paul under the title, "A Case of Abnormal Cardiac Position (Levoposition)" in *Circulation*, 1959, *19*, 750–752, has roentgenographic and clinical features so similar to our cases that we believe the patient very probably represents another example of congenital deficiency of the left pericardium.

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REFERENCES

1. Abbott, M. Congenital Cardiac Disease. Reprinted from Osler and McRae's Modern Medicine. Vol. IV. Second edition, 1915, pp. 344–345.
2. Adsersen, W. Contributo alla casistica sul difetto congenito del pericardio e sulla rottura della milza. *Gass. osp.*, 1887, *8*, 443.
3. Arndt. Nabelschnurbruch mit Herzhernie. *Zentralbl. f. Gynäk.*, 1896, *20*, 632.
4. Baillie, N. On want of pericardium in human body. *Tr. Soc. Imp. Med. & Chir. Knowledge*, 1793, *1*, 91–102.
5. Baly, W. Absence of pericardial sac, heart lying in cavity of left pleura. *Tr. Path. Soc., London*, 1850, *3*, 60–63.
6. Barsoum, H. Absence of pericardium. *Brit. M. J.*, 1935, *2*, 666.
7. Beck, C. S. Congenital deficiency of pericardium. *Arch. Surg.*, 1931, *22*, 282–288.
8. Beyer, R. Über angeborene Herzbeuteldefekte. *Ztschr. f. Kreislaufforsch.*, 1938, *30*, 411–417.
9. Björnström, J. S. Malformation of pericardium. *Tr. Path. Soc., London*, 1854, *109*.
10. Blalock, A. Exposure of heart to atmospheric pressure; effects on cardiac output and blood pressure. *Arch. Surg.*, 1933, *26*, 516–521.
11. Boxall, R. Incomplete pericardial sac; escape of heart into left pleural cavity. *Tr. Obst. Soc., London*, 1887, *28*, 209–210.
12. Breschet, G. Mémoire sur un vice de conformation congénitale des enveloppes du coeur. *Ré-*

pért. gén. d'anat. et physiol. path., 1826, *1*, 67–74.

13. Bristowe, J. S. Malformation of pericardium and left pleura. *Tr. Path. Soc., London*, 1854, *6*, 109–112.
14. Brunner. Dissertatio de corde occulto. Anno 1701.
15. Buttner, G. C. Anatomische Wahrnehmung. Koenigsberg und Leipzig. 1768, *36*.
16. Cameron, A. L. Defects of parietal pericardium. *Tr. Chicago Path. Soc.*, 1914, *9*, 148–155.
17. Canavan, M. M. Adult heart with deficient pericardium. *J.A.M.A.*, 1924, *82*, 716.
18. Chase, M. R. Congenital deficiency of pericardium. *J. Anat. & Physiol., London*, 1915–16, *1*, 299–302.
19. Chiari, H. Ueber einen Fall von fast vollständige n Defekte des Pericardium parietale. *Wien. med. Wchnschr.*, 1880, *30*, 372.
20. Chiodin, L. A. Aplasia congénita de la hoja parietal del pericardio. *Rev. Soc. argent. de biol.*, 1932, *8*, 361–367.
21. Columbus, M. R. De re anatomica. Vol. XV. 1559, p. 265.
22. Curling, T. B. Case of congenital absence of pericardium with observations. *Tr. Med. Chir. Soc., London*, 1839, *22*, 222–230.
23. Dahl, E. Et. tilfelle av medfodt pericarddefekt diagnostisert after anleggav venstresidig pneumothorax. *Med. rev. Bergen*, 1937, *54*, 312–315.
24. De Cardenal, G., and Bourderou. *J. Méd. Bourdeaux.*, 1903, *23*, 222.
25. De Garis, C. F. Pericardial patency and partial ectocardia in newborn orang-utan. *Anat. Rec.*, 1934, *59*, 69–82.
26. De Torres, J. I. Extraordinary case of heart of a child turned upside down. *Philosophical Tr. Roy. Soc., London*, 1735–43, *8*, 508.
27. Ebstein, E. Bemerkungen zur Klinik der Herzbeuteldefekte. *München. med. Wchnschr.*, 1910, *57*, 522–524.
28. Egbert, D. S., and Little, S. Congenital pericardial deficiency with other anomalies; report of case with necropsy findings. *Yale J. Biol. & Med.*, 1935, *8*, 19–22.
29. Faber, C. Ueber den angeborenen Mangel des Herzbeutels. *Virchow's Arch. f. path. Anat.*, 1878, *74*, 173.
30. Fanfani, M., and de Biase, G. Le agenesie del pericardio. *Arch. "de Vecchi" anat. pat.*, 1954, *22*, 1003–1063.
31. Grant, R. T. Congenital pericardial deficiency. *Heart*, 1926, *13*, 371–379.
32. Gross, R. E. Congenital hernia of diaphragm. *Am. J. Dis. Child.*, 1946, *71*, 579–592.
33. Gruber, C. B. Zur Kenntnis kranialer Doppelbildung beim Menschen mit Zwerchfellsfehlern und mit Herzbeutel-Lunge. *Beitr. path. Anat.*, 1949, *110*, 346–360.
34. Henkel, J. A. De pericardio deficiente. Berolini, 1828.
35. Hewson, A. Absence of fibrous pericardium on left side. *Proc. Assn. Am. Anat.*, 1896, *8*, 34.
36. Hoyer, J. G. De raris et curiosis in anatomicis variorum cadoverum sectionibus repertis. *Acta Phys. Med. Nat. cur.*, 1740, *5*, 254.
37. Hughes, W. E. Phthisis: Absence of parietal pericardium: Malposition of liver. *Tr. Path. Soc., Philadelphia*, 1886, *12*, 73–75.
38. Kadin, M. Congenital deficiency of pericardium. *Michigan M. Soc.*, 1939, *38*, 503–506.
39. Keith, A. Remarks on diaphragmatic hernia. *Brit. Med. J.*, 1910, *2*, 1297–1298.
40. Keith, J. A. Partial deficiency of paricardium. *J. Anat. & Phys.*, 1907, *41*, 6–7.
41. Kerley, P. A Textbook of X-Ray Diagnosis. Second edition. Edited by S. C. Shanks and P. Kerley. Vol. II. W. B. Saunders Company, Philadelphia and London, 1951, pp. 146–147.
42. Ladd, W. E. Congenital absence of pericardium. *New England J. Med.*, 1936, *214*, 183–187.
43. Lang, F. J. Zur Kenntnis der angeborenen Herzbeuteldefekte. *Virchow's Arch. f. path. Anat.*, 1921, *230*, 608–621.
44. Lebec, M. Absence du péricarde par arrêt de développement. *Bull. Soc. Anat. de Paris*, 1874, *49*, 455–457.
45. Littrè, M. *Mém. de l'Acad. Roy. des Sciences*, Paris, 1712, p. 36.
46. Martland, H. S. Case of congenital false diaphragmatic hernia. *J.A.M.A.*, 1909, *52*, 1574–1576.
47. McCrory, W. W., and Bunch, R. F. Omphalocele with diaphragmatic defect and herniation of liver into pericardial cavity. *J. Pediat.*, 1947, *31*, 456–464.
48. McGarry, K. A. Case of patency of pericardium and its embryological significance. *Anat. Rec.*, 1914, *8*, 43–54.
49. Meckel, J. F. Descriptio monstrorum nonnullorum cum corollaris anatomico physiologicis. Lipsiae sumpt. h. Vossii, 1826, p. 12.
50. Ménière, M. P. Observation d'un vice de conformation du péricarde. *Arch. gén. de méd.*, Paris, 1826, *10*, 94–97.
51. Mönckeberg, J. G. In: Henke, F., and Lubarsch, O., Editors. Handbuch der speziellen pathologischen Anatomie und Histologie. Vol. II. Springer-Verlag, Berlin, 1924, pp. 20–21.
52. Moore, R. L. Congenital deficiency of pericardium. *Arch. Surg.*, 1925, *11*, 765–777.
53. Moore, T. C., and Shumacker, H. B., Jr. Congenital and experimentally produced pericardial defects. *Angiology*, 1953, *4*, 1–11.
54. Nicoli, L. Assenza del sacco pericardico. *Boll. d. Soc. med.-chir. di Pavia*, 1929, *4*, 499–513.
55. O'Brien, H. D. Pericardio-peritoneal communication. Description of rare type of diaphragmatic hernia. *J. Anat.*, 1939, *74*, 131–134.

56. Orth, J. Lehrbuch der speciellen pathologischen Anatomie. Vol. I. A. Hirschwald, Berlin, 1887, pp. 126–128.
57. Osgood, R., and Spector, B. Defective pericardial sac and interatrial septum and atresia of pulmonic orifice. *Am. J. Dis. Child.*, 1941, *61*, 1028–1033.
58. Otto, A. W. Neue seltene Beobachtungen zur Anatomie, Physiologie und Pathologie. A. Rücker, Berlin, 1824, No. 2, p. 44.
59. Patten, B. M. Human Embryology. Second edition. McGraw-Hill Book Co., New York, 1953.
60. Peacock, T. B. On Malformations of the Heart. J. & A. Churchill, Ltd., London, 1866.
61. Perna, G. Sopra un arresto di sviluppo della sierosa pericardica nell'uomo. *Anat. Anz.*, 1909–1910, *35*, 323–338.
62. Picchi, L. Due rari casi di malformazione pericardica. *Sperimentale Arch. di biol.*, 1907, *61*, 375–379.
63. Pisek, W. Wrodzony brak Norka sercowego przy prawidlowem polozeniu serca (Congenital absence of pericardium). *Przegl. lek.*, 1883, *22*, 373.
64. Plaut, M. Ueber zwei weitere Fälle von Defekt des Herzbeutels. *Frankfurt. Ztschr. f. Path.*, 1913, *12*, 141–156.
65. Powell, R. D. Deficiency in pericardium. *Tr. Path. Soc. London*, 1868, *20*, 99–100.
66. Primrose, E. J. Patency of pericardium; solitary kidney; septum in urinary bladder. *Glasgow M. J.*, 1902, *56*, 184–189.
67. Risel. Canalis neurentericus und Rhachischisis anterior (Drei Fälle von Persistenz des Canalis neurentericus bei Rhachischisis anterior mit Störungen in Schluss des Zwerchfells). *Verhandl. d. deutsch. path. Gesellsch.*, 1912, *15*, 379–415.
68. Ronka, E. K. F., and Tessmer, C. F. Congenital absence of pericardium. *Am. J. Path.*, 1944, *20*, 137–141.
69. Rusby, N. L., and Sellors, T. H. Congenital deficiency of pericardium associated with bronchogenic cyst. *Brit. J. Surg.*, 1945, *32*, 357–364.
70. Saxer. Die Brustorgane einer 38 jährigen Frau mit fast vollständingem angeborenen Mangel des Herzbeutels. *München. med. Wchnschr.*, 1902, *49*, 838.
71. Schindewolf, K. J. Ein Fall von Herzbeuteldefekt. Inaug. Dissert., Marburg, C. L. Pfeil, 1900.
72. Schmincke. Missbildung des Herzbeutels. *Deutsche med. Wchnschr.*, 1912, *38*, 2246.
73. Shafiroff, B. G. B. Congenital absence of pericardium; case report. *J. Thoracic Surg.*, 1951, *21*, 30–33.
74. Sievers, R. Grosser Nabelschnurbruch mit vorderer Zwerchfellücke und situs inversus partialis der Bauchorgane. *Arch. f. Klin. Chir.*, 1938, *153*, 703–733.
75. Southworth, H., and Stevenson, C. S. Congenital defects of pericardium. *Arch. Int. Med.*, 1938, *61*, 223–240.
76. Sunderland, S., and Wright-Smith, R. J. Congenital pericardial defects. *Brit. Heart J.*, 1944, *6*, 167–175.
77. Tait, L. Congenital absence of pericardium. *Dublin Quart. J. Med. Sc.*, 1869, *47*, 85–90.
78. Tulpius, N. Observationes medicae. Lib. II. Amstelaedami, 1657, Cap. 25, p. 143.
79. Venturini, A., and Pesci, A. Le agenesie del pericardio. *Arch. chir. torace.*, 1957, *14*, 189–202.
80. Verbeeck, F. E. *N. Verh. v. h. Kon.-Nederlinst*, 1827, *1*, 229–239.
81. Versé, M. Fall von kongenitalem Defekt des Herzbeutels. *München. med. Wchnschr.*, 1909, *56*, 2665–2666.
82. Vieussens, R. Traité nouveau de la structure et des causes de mouvement naturel du coeur. Ed. 3e Jean Guillemette, Toulouse, 1715.
83. Walter, J. G. Frederici Wilhelmi tertii . . . qua majora inde res medica ac chirurgica in posterorum salutem capiat incrementa. Museum Anatomicum Berolini, 1805, p. 86.
84. Watt, J. C. Rare congenital deficiency of pericardium. *Arch. Surg.*, 1931, *23*, 996–1006.
85. Weber, H. Baldinger's Magazin für Aerzte. Leipzig, 1790, *6*, 510.
86. Weisbach, A. Angeborener Defekt des Herzbeutels. *Wien. med. Wchnschr.*, 1868, *18*, 1109.
87. Wolf. Fall von Entbindung nach dem Tod und von Mangel des Herzbeutels. *Roust's Magaz. f. die ges. Heilk.*, 1827, *23*, 333–335.

EYE GLASSES FOR THE RADIOLOGIST*

By FRANK A. RIEBEL, M.D.
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THE radiologist's skill depends so much on the health and efficiency of his eyes that they deserve utmost care. Since most radiologists do, or eventually will, need glasses, some of the elements for visual correction are described here.

THE PRESERVATION OF DARK ADAPTATION

Many have observed that dark adaptation is delayed by exposure to bright sunlight. As a consequence, some physicians have tried to wear red goggles while driving from one fluoroscopic session to another. This is nearly futile, inasmuch as only one and one-half minutes of adaptation time can be saved in this way if one goes directly to fluoroscopy[6] and no time is saved if other tasks are performed prior to fluoroscopy. It is significant to radiologists that there is a gradual decrease of visual acuity during the summer, as shown by Peckham and Harley[5] who studied 70 life guards at Atlantic City. This loss of acuity can be prevented by wearing very dark sun glasses of about 10 to 15 per cent transmission. This loss of visual acuity cannot be prevented by wearing commercially produced sun glasses of 35 to 50 per cent transmission.

The following are some of the darker lenses available with their characteristics, as reported by the manufacturers:

	Color	*Visual Transmission (per cent)*
Contra-Glare D	green	11.8
Ray Ban G-15	gray	15
T/O—20	gray	19.8
Cosmatan	brown	21
Calabar Polaroid	green	20–30
Contra-Glare C	green	28.7
Ray Ban #3	green	30
A.O. Neutral Polaroid	green	30–35
Calabar D	green	36

Any of these lenses can be obtained from an optician as frame or clip-on sun glasses, or ground with corrective prescriptions. Contra-Glare D and Ray Ban G-15 of this list best meet the requirements of the radiologist. To be effective, however, they must always be worn whenever the radiologist goes out into brilliant sunlight.

FLUOROSCOPY WITH PRESBYOPIA

It is not unusual to find the aging roentgenologist retiring from fluoroscopy before he leaves his other work. Three factors may be handicapping him. First, he may not realize that the rate of dark adaptation is a function of age.[1] This is borne out by studies which show that for every thirteen years of maturity the intensity of illumination must be doubled to make a threshold target visible to the dark adapted eye.[2,4] These experiments were made with an artificial pupil and with the use of mydriatics. Secondly, in addition to the above, the ability of the pupil to dilate diminishes with age.[8] Some compensation for these two factors can be achieved by a longer adaptation time and adjustment of milliamperage or voltage. Thirdly, special refractive errors are always present at the fluoroscopic screen.

If the seated fluoroscopist wears glasses, he normally looks through the centers of his lenses as he views the abdomen. If he wears bifocals he is, perhaps unknowingly, accepting a refractive error. This is understandable for he does not observe the image jump between the two segments of his lens, as his pupils are dilated and over an intermediate band he is looking through lenses of two different corrections. These two lenses give two magnifications, and moreover are on different optical centers (which is the cause for the usual image jump). For example, if the fluoroscopist looks up from the abdomen to view the chest, the image

* From the Department of Radiology, Medical Center, Ohio State University, Columbus, Ohio.

of chest structures is unsharp because his upper segment is of the wrong focal length. Only when he views the horizontal patient can he conveniently look downward through the small lower segments; but the radiologist who has developed presbyopia has surely become habituated to using peripheral vision at low brightness levels, and thus his eyes will rove outside the confines of his reading segments, with the resultant additional refractive error.

What is the remedy?

OCCUPATIONAL LENSES FOR FLUOROSCOPY AND FILM READING

There is no such thing as an all-purpose pair of lenses in presbyopia according to Holmes,[3] whose magnificent guide describes the visual needs for 1,000 occupations. Holmes states that the professions are rapidly coming to accept the principle that multiple prescriptions are the only alternative to diminished vision in the aging. If we accept this principle, how shall it be applied in fluoroscopy?

Solution 1. Single vision lenses can be prescribed for any desired focal distance. A convenient one could have a focus midway between the distant and near foci. This will solve the problem for fluoroscopy, but may not satisfy for other situations which occur in the radiologic department, the principal one being the reading of roentgenograms. Here, the ordinary bifocals do not meet all requirements. The upper segment gives insufficient correction, and it is mechanically inconvenient to view all of a film, or several in bank, with the small lower segments.

Solution 2. Trifocals. At first thought this should be ideal, inasmuch as the middle segment can give just the right acuity for film viewing. There is, however, a serious fault with the trifocal lenses, *i.e.*, the height of the middle segment is usually 6 to 8 mm., which means a restricted field in the vertical direction. (A 7 mm. segment gives a field of 8 cm. at 50 cm. focus).[3] The scanning and much of the interpreting of roentgenograms is done with peripheral vision. For example, about three and one third of these printed pages equal a 14 inch × 17 inch film. The pages could scarcely be read in less than five minutes, nor can such a roentgenogram be read in less time unless peripheral vision is used to scan for areas of interest. Some occupational lenses have been designed with a wide middle segment to meet such needs.[3,7] However, even a 10 mm. middle segment will not give a large enough visual field to allow scanning, and it cannot be greater and yet leave space large enough for distance and reading segments.

Solution 3. The single vision lenses for fluoroscopy are used for film reading also. These are excellent at medium distances, but in advanced presbyopia one cannot view a roentgenogram held closely so as to inspect fine detail.

Solution 4. To meet the above need, add a reading segment to the occupational lenses; these should be placed low to avoid their use in the fluoroscopic field.

Solution 5. Although occupational lenses are the best visual solution, perhaps a compromise can be reached with bifocals which have segments for distance. The reading segments of the latter, as usually prescribed, are inappropriate for either film reading or fluoroscopy for two reasons. First, the segments are small and located low, so that a large field cannot be viewed conveniently, even with excessive head tilt. Secondly, there is image jump, which disturbs most bifocal wearers to some degree. To reach a solution for our dilemma it is necessary to understand the optical principles involved.

The original bifocals were invented by Benjamin Franklin, who simply cut the upper and lower segments with the same optical center but of different focal lengths and cemented them together. Because of their unsightliness, these were later replaced by single pieces of glass made by fusing two glasses of unlike refractive indices and grinding them on different optical centers; this produces the image jump.

The AO Executive bifocal (Fig. 1) meets

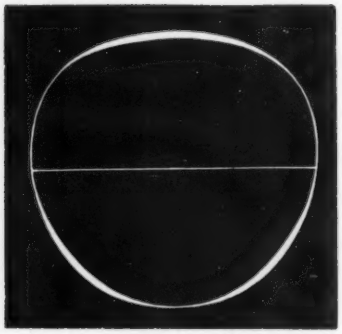

Fig. 1. An eye glass of the above design gives a lower segment large enough for film viewing and produces no image jump, since it is monocentric. The dividing line between the segments is more noticeable than in the usual fused bifocals. (By permission of the American Optical Co.)

this difficulty by being monocentric, thus eliminating the annoying jump. It can be an all-purpose bifocal including film reading and fluoroscopy as long as the add in the lower segment is not excessive. The upper half of the lens is adequate for distant vision, and through the lower half a large film can be seen at the near distance in comfort, which is not true of the small low-placed segments found in ordinary bifocals. Similarly, it meets the needs of the fluoroscopist. Only in advanced presbyopia need one switch to occupational lenses. A minor drawback to the AO Executive bifocal is that the dividing line between the fields is more easily seen by both wearer and viewer, as compared to the bicentric type.

TYPES OF GLASS. RADIOPACITY

With an increasing awareness of radiation hazards and the broadening of the field, as in the case of isotopes, most of us are seeking all the protection we can get. Fortunately, the eyes are highly radioresistant, although the lens is not altogether exempt from damage to excessive exposure. In fluoroscopy good protection is afforded by the screen itself. Nevertheless, some radiation protection can be afforded if the proper optical glass is used.

Single vision lenses or the major portion of a bifocal are made of crown glass, composed principally of sodium boro-silicate. The lower segment is usually either flint glass (which has a high lead content) or barium glass, each of which is relatively radiopaque (Fig. 2). A single vision lens can be ground from flint glass if desired. A commercial variety called Thin-lite has a

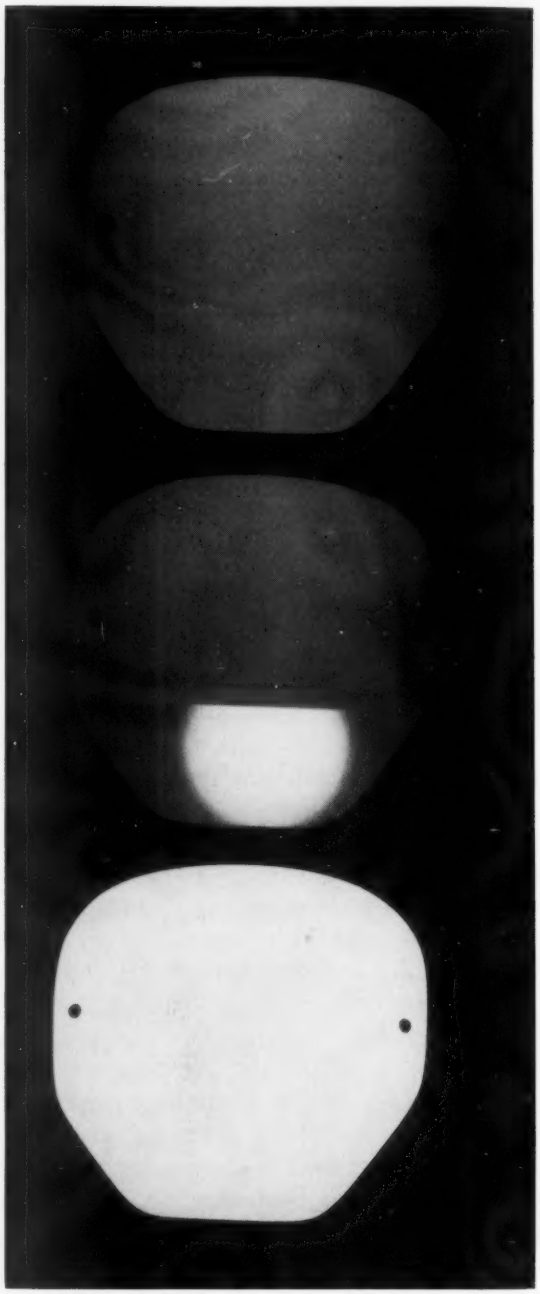

Fig. 2. Eye glasses can be ground either from crown glass (above) or radiopaque flint glass (below). Bifocals are usually ground from blanks formed by fusing the two kinds of glass (center).

lead equivalent of .4 mm. for glass 2 mm. thick, and is available through any optician. However, satisfactory radiopaque bifocals have not yet been developed.

SUMMARY

1. Visual acuity is diminished for long periods by exposure to intense sunlight. Consequently, the radiologist suffers a significant functional loss of ability to fluoroscopy in the summer unless he wears sun glasses allowing no more than 15 per cent visual transmission. These must be worn on every occasion whenever he exposes himself to the summer sun. Ray Ban G-15 and Contra-Glare D are two commercially available types which afford adequate protection.

2. Those who wear bifocals will not distinguish between the major and reading segments during fluoroscopy because of pupillary dilatation. Consequently, spherical aberration may be dulling the naturally low visual acuity at low brightness levels. This can be avoided by using occupational single vision lenses ground for an appropriate distance, or bifocals with exceptionally large reading segments, such as are described herein.

3. For film reading no trifocal can correct a large enough visual field. Better solutions are to use special bifocals with a large reading segment, or single vision lenses for intermediate distance. These can be the same glasses as are used for fluoroscopy.

4. Single vision eye glasses can be ground from flint glass which will afford significant protection from radiation, if that feature is desired.

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REFERENCES

1. Birren, J. E., Bick, M. W., and Fox, C. Age changes in light threshold of dark adapted eye. *J. Gerontol.*, 1948, *3*, 267–271.
2. Guth, S. K. Effects of age on visibility. *Amer. J. Optometry*, 1957, *34*, 463–477.
3. Holmes, C. Guide to Occupational and Other Visual Needs. Volume I. Anderson, Ritchie and Simon, Los Angeles, 1958.
4. McFarland, R. A., and Fisher, M. B. Alterations in dark adaptation as function of age. *J. Gerontol.*, 1955, *10*, 424–428.
5. Peckham, R. H., and Harley, R. D. Reduction in visual acuity due to excessive sunlight. *A.M.A. Arch. Ophth.*, 1950, *44*, 624–627.
6. Riebel, F. A. Efficiency of red goggles. Am. J. Roentgenol., Rad. Therapy & Nuclear Med., 1953, *70*, 827–830.
7. Sampson, D. A. Wide-angle trifocal eyeglasses for radiologists. *Radiology*, 1954, *62*, 255–258.
8. Seitz, R. Die Altersabhängigheit der Pupillenerweiterung bei Dunkel Adaptation. *Klin. Monatsbl. Augenh.*, 1957, *131*, 48–57.

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EDITORIALS

SIXTIETH ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY

THE Sixtieth Annual Meeting of the American Roentgen Ray Society will be held at the Netherland Hilton Hotel, Cincinnati, Ohio; Tuesday, Wednesday, Thursday and Friday, September 22 through 25, 1959. It was in 1953 that the American Roentgen Ray Society last met in Cincinnati. That meeting and previous ones held at the Netherland Hilton were so successful that one has every expectation that the forthcoming meeting should be equally informative and entertaining. The Committee on Local Arrangements headed by Dr. Harold G. Reinecke, and the Ladies' Committee of which Mrs. Reinecke is Chairman, will again afford the hospitality and organization that they have so capably demonstrated in the past.

The Manager of the Annual Meeting, Dr. James C. Cook, and Mr. Clifford L. Sherratt have arranged that the numerous commercial exhibits be set up in the Hall of Mirrors, the Hall of Mirrors Foyer and in the South Hall. The commercial exhibits will be open from 8:30 A.M. to 5:00 P.M. The Scientific Exhibits Committee, Dr. Richard H. Marshak, Chairman, Dr. Ted F. Leigh and Dr. Charles O. Heilman, has succeeded in obtaining excellent exhibits which should be of great teaching value. These will be on display in the North Hall, Parlors A, B, C, and D, and the Julep Room on the third floor. The Committee plans to keep the exhibits open until 8:00 P.M. on Tuesday, and 9:00 P.M. on Wednesday. On Thursday, September 24, because of the Annual Banquet, the scientific exhibits will remain open only until 7:30 P.M.

The Annual Golf Tournament for members and guests will be held at the Kenwood Country Club, Monday, September 21. Arrangements have been made by the local golf committee for bus transportation to and from the Country Club, and for luncheon, golf and dinner. It is hoped that following dinner, as on previous occasions, moving pictures of previous tournaments will be shown. The Willis F. Manges Trophy for the Eighteen Hole Medal Handicap, the Exhibitors' Trophy for the Eighteen Hole Gross Score and other prizes will be awarded.

Registration for the meeting begins at 2:00 P.M. on Sunday, September 20, and thereafter the registration desk will be open from 8:00 A.M. to 5:00 P.M. in the Pavillon Caprice Foyer.

The meeting of the Society will formally open at 8:30 in the morning, Tuesday, September 22, with an address by Mr. Walter Langsam, President of the University of Cincinnati, following the call to order by President Barton R. Young. The Chairman of the Executive Council, Dr. Arthur E. Childe, will assist Dr. Young in the installation of the President-Elect, Dr. Edward B. D. Neuhauser.

The Program Committee has selected more than 40 outstanding papers for presentation. On Tuesday morning, nearly all of the papers to be given will be devoted to significant and practical aspects of neuroradiology.

The Caldwell Lecture will be given Tuesday evening in the Pavillon Caprice at 8:15 by Dr. Donald McRae, Associate Professor of Radiology at McGill University, and head of the Department of Neuroradiology at the Montreal Neurological Institute. Dr. McRae is an outstanding Neuroradiologist, a past president of the International Neuroradiological Society, and a

brilliant and lucid speaker. He will be introduced by Dr. Carlton Peirce, Professor of Radiology, McGill University, and Chairman of the Department at the Royal Victoria Hospital, Montreal.

Wednesday morning, beginning at 8:30, Dr. John Caffey will serve as Moderator of an excellent series of papers on Pediatric Radiology. Particularly significant will be a group of papers devoted to recently described forms of pneumonia.

The papers to be given on Thursday morning are of varied subject matter but have been chosen because of their present significance and wide appeal.

The presentations on Friday morning reflect the great and growing interest in radiation research and radiobiology.

Dr. Harold O. Peterson, Director of the Instructional Courses, has again chosen a fine faculty, which is to give over 60 courses. The excellent instructors of the past have been retained and a number of new faculty members has been recruited. Instructional Courses will be held Tuesday, Wednesday, and Thursday afternoon from 3:00 to 4:30, and Friday afternoon from 1:30 to 3:00. Details of the Courses will be published in the August issue of the JOURNAL. Members and guests will be required to fill out application blanks for the Courses they desire to take, and will receive tickets in advance of the meeting.

The Annual Banquet will be held in the Pavillon Caprice at 7:30 P.M. on Thursday, September 24. It will be preceded by a cocktail party in the Caprice Suite beginning at 6:30. The Program Committee, knowing the wide intellectual interests of Radiologists and their wives, has invited Professor Emmett O'Grady, head of the Department of English at the University of Ottawa, to give an after-dinner talk in the field of the humanities. Professor O'Grady, who is widely known on the television circuits of Canada, has chosen to speak on "Levity and Learning in Literature."

A cordial invitation to attend the meeting is extended by the officers of the Society to all radiologists, their wives and guests.

EDWARD B. D. NEUHAUSER, M.D.
President-Elect

The Children's Medical Center
300 Longwood Avenue
Boston 15, Massachusetts

MERRILL CLARY SOSMAN
1890–1959

ON MARCH 28, 1959, Merrill C. Sosman died in his 68th year of life as a result of complications of a cerebrovascular accident. Characteristically, he was "at work" when first afflicted, lecturing on experiences of his recent round-the-world medical trip, sponsored in part by the United States State Department.

Dr. Sosman was born in Chillicothe, Ohio, graduated with an A.B. degree from the University of Wisconsin in 1913 and an M.D. degree from the Johns Hopkins Medi-

cal School in 1917. His internship was interrupted by World War I and he entered the Army Medical Corps in 1918 and was assigned to a radiologic post, his initial firsthand contact with radiology. From 1919–1921 he served as Roentgenologist at the Walter Reed General Hospital, Washington, D. C. The decision to remain in radiology was the result of the early guidance and stimulus of the late, great pioneer of radiology, Dr. George Holmes, with whom he finished training at the Massachusetts General Hospital in 1922. In the same year he accepted the post of Roentgenologist at the Peter Bent Brigham Hospital and became Assistant in Roentgenology at the Harvard Medical School. This was the era of radiologic infancy. His immediate medical environment was dominated by the impact of the contributions of strong and great men—Henry Folin, Walter B. Cannon, Harvey Cushing, Henry Christian, Bert Wolbach, Soma Weiss and Sam Levine. It was in this atmosphere that he grew and thrived. And it was in the subsequent thirty-five years, serving and leading in these same institutions, that he continued to learn his radiology, as he so often said. It was during these years that he sold radiology as a science, not as an aggressive salesman, but by constant demonstration within the hospital and to his colleagues, here and abroad, of what radiology could contribute as a medical specialty. This went far in helping establish recognition of the specialty as a science in a period and area in which the early achievements of the radiologist were looked upon, at times, with considerable doubt. Sosman, the student in quest of knowledge, as he liked to categorize himself, taught medical students, residents and postgraduates and published over 121 medical articles during his time. In both, he has left a lasting mark on this world.

Dr. Sosman impressed much of the character on radiology as it is practiced in the area today, during the years in which he rose to be Professor of Radiology, Harvard Medical School, at the Peter Bent Brigham Hospital. In this period he became the acknowledged master, as teacher and practitioner of clinical radiology: master in the sense of scholar of authority; master in the sense of artist of distinguished skill. It was perhaps characteristic of Dr. Sosman that he was not a strong organization man but the national radiological societies and medical organizations recognized his achievements and honored him on numerous occasions. Among these were President of the American Roentgen Ray Society, 1940; Caldwell Lecturer, 1947; Gold Medal Recipient of the Radiologic Society of North America, 1957; Carman Lecturer, 1948; President of the Cushing Society; President of the New England Roentgen Ray Society; Annual Oration of the Massachusetts Medical Society, 1956; Honorary Masters Degree from Harvard University; Member of the American Academy of Arts and Sciences.

Dr. Sosman, the person, meant many things to many people, often quite apart. A character of insatiable intellectual curiosity, indefatigable drive and an almost incredible self-discipline was almost hidden in the transient encounter by the flexibility of his personality, a delightful wit, and an avid capacity to appreciate the moment, the immediate experience.

This was a rare dichotomy, which enabled him to steer the most rigid predetermined course through a medical teaching session, a working day, a scientific treatise, even through life with apparent ease and grace but with a deep comprehension of it all.

This indeed permitted the occasional humiliation of the student, the provocative needling of a professional associate as a device for teaching, as there was complete detachment with no malice. This permitted an eager step into the limelight as there was no deep-seated arrogance. To those who knew him best, he was basically a humble man.

After his retirement from the Peter Bent Brigham Hospital and the Harvard Medical School in 1956, he and his wife em-

barked on the medical lecture trip which took him around the world. Since January, 1958, he served as active Consultant in Radiology at the Massachusetts General Hospital, where he carried on until the end. He leaves his devoted wife, Arlene Adams Sosman, a son, Dr. J. Leland Sosman, a daughter, Mrs. Barbara Munson and six grandchildren.

M. H. Wittenborg, M.D.

GOTTWALD SCHWARZ
1880–1959

GOTTWALD SCHWARZ, formerly Professor of Radiology in the University of Vienna, died February 26, 1959 in New York, at the age of seventy-eight. Professor Schwarz was born in 1880 in Brünn, Moravia, then a part of Austria. When he was two years old, the family moved to Vienna, where he received his education, graduating from the Medical Faculty of the University of Vienna as a Doctor of Medicine in 1904. While still a medical student, he became fascinated with the roentgen rays, and foresaw great possibilities in fluoroscopic and roentgeno-

graphic medical diagnosis as well as in therapy and biologic research.

As a member of the Holzknecht Institute, while still a medical student he published in 1903 his first paper on the effect of radium rays on chick eggs. In 1907 he found that x-rays precipitated calomel from an ammonium sublimate preparation and he used this reaction for one of the earliest scientific methods for the measurement of x-ray dosage. During the early days of roentgenology Professor Schwarz published many important papers on the influence of x-rays on the blood and bone marrow. He studied extensively the problem of x-ray sensitivity and the resistance of various tissues to x-rays, and sought to find means of increasing or decreasing the sensitivity of skin areas of portals used for radiation therapy.

Many of his early achievements in the diagnostic field related to the gastrointestinal tract and the cardiovascular system.

In 1910 he was first to observe fluoroscopically the pulsation of the hilar shadows, demonstrating that they were produced mainly by the pulmonary vessels; the x-ray aspect of the epicardial fat pad; and many other details of these systems. His studies on gastric and colonic peristalsis and methods for the early diagnosis of cancer of the colon were described in a published book shortly after World War I, at which time he had been promoted to the position of Titular Professor in the University of Vienna. He was also made head of the department of radiology at the Empress Elizabeth Hospital. Professor Schwarz recognized the advantages of fractionated doses over massive doses about five years before Coutard's famous paper appeared. His published treatises include 68 articles on diagnostic and physiologic subjects, and about 70 articles on radiotherapy and radiobiology. In 1937 he co-authored a book entitled "Diagnosis and Nonoperative Treatment of Diseases of the Colon and Rectum." The use of tannic acid in connection with barium enema studies of the colon introduced by Schwarz in 1918 became popular in the United States ten years after he had discarded it. Only a few of his accomplishments have been mentioned.

At the time of the writer's contact with Doctor Schwarz, he was radiologist in the Second Medical Clinic in Vienna at the Allgemeines Krankenhaus. It was his pleasure and privilege to know Doctor Schwarz intimately from 1907 on.

Professor Schwarz was head of the Austrian delegation to the 1937 International Congress of Radiology in Chicago; and shortly after that when Hitler occupied Austria, he lost all his possessions and took refuge in England. Finally in 1940 at the age of fifty-eight he succeeded in gaining entrance into the United States, where he qualified for a license in New York and practiced roentgenology in New York until at the age of seventy-seven he went into retirement.

Doctor Schwarz was not only a great scientist but was active in the field of literature and a lover of classical music and art. He had a wonderful personality and made many friends. Many American radiologists have warm memories of the kind attentions received at the hands of this great radiologist.

Doctor Schwarz is survived by his wife and his son, Gerhart Schwarz, also a radiologist known to a great many of us. Our sincere sympathy goes out to them.

James T. Case, M.D.

PRELIMINARY PROGRAM

SIXTIETH ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY

The Sixtieth Annual Meeting of the American Roentgen Ray Society on September 22 to September 25, 1959, will be held at the Netherland Hilton Hotel, Cincinnati, Ohio.

The Executive Council will meet on Sunday, September 20.

The Kenwood Country Club will be the site of the Annual Golf Tournament for the Willis F. Manges Trophy for the Eighteen Hole Medal Handicap and the Exhibitors' Trophy for the Eighteen Hole Gross Score on Monday, September 21. After the tournament, the two trophies and also other prizes will be awarded at the Annual Golf Dinner.

This year's Caldwell Lecture will be delivered on Tuesday evening, September 22, by Dr. Donald L. McRae, Associate Professor of Radiology in the Department of Radiology, and Associate Professor of Neuroradiology in the Department of Neurology and Neurosurgery, McGill University, Montreal, Canada, in the Pavillon Caprice.

The Instruction Courses will be held each afternoon, Tuesday through Friday. A detailed plan of the courses will be published in the August issue of the JOURNAL.

President-Elect Edward B. D. Neuhauser and his Committee have arranged the Scientific Program of the Meeting, which is as follows:

Tuesday, September 22, 1959
Pavillon Caprice

8:30 A.M. Call to Order, Sixtieth Annual Meeting, Barton R. Young, M.D., President. Address of Welcome: Mr. Walter C. Langsam, President, University of Cincinnati.

Installation of the President-Elect, Edward B. D. Neuhauser, M.D., Boston, Mass., by President Barton R. Young, M.D., Philadelphia, Pa., and Arthur E. Childe, M.D., Chairman of the Executive Council, Winnipeg, Manitoba, Canada.

Inaugural Address: President Edward B. D. Neuhauser, M.D. Planning the Program.

9:15 A.M.

Presiding: Edward B. D. Neuhauser, M.D.
Boston, Mass.

1. Intracranial Sarcomas: Their Roentgenographic Manifestations. Hillier L. Baker, Jr., M.D. (by invitation), Rochester, Minn.
2. Hemicranial Aplasia with Pulsating Exophthalmos. An Unusual Manifestation of von Recklinghausen's Disease. Richard L. Rovit, M.D. (by invitation), Montreal, Que., Canada, and Merrill C. Sosman, M.D., Boston, Mass. (deceased).
3. Papillary Adenoma of the Choroid Plexus. Donald D. Matson, M.D. (by invitation), and Francis D. L. Crofton, M.D. (by invitation), Boston, Mass.
4. The Cavum Veli Interpositi and Its Differentiation from Cavum Vergae. Hans Zellweger, M.D. (by invitation), and Eugene F. Van Epps, M.D., Iowa City, Iowa.
5. The Roentgen Diagnosis of Intracranial Incisural Space Occupying Lesions. Juan M. Taveras, M.D., New York, N. Y.
6. Neurogenic Tumors of the Mediastinum —A Clinical Pathological Study. Lewis S. Carey, M.D. (by invitation), Minneapolis, Minn., F. Henry Ellis, Jr., M.D. (by invitation), Rochester, Minn., C. Allen Good, M.D., Rochester, Minn., Lewis B. Woolner, M.D. (by invitation), Rochester, Minn.
7. The Classification of Cervical Spine Injuries. Joseph E. Whitley, M.D. (by invitation), and H. Francis Forsyth, M.D. (by invitation), Winston-Salem, N. C.
8. The Radiological Diagnosis of Mesentericoparietal Herniations. R. L. Estrada, M.D. (by invitation), J. W. McKay, M.D. (by invitation), and D. J. Sieniewicz, M.D. (by invitation), Montreal, Que., Canada.
9. Ovarian Irradiation and the True Hormonal Menopause. James B. Dealy, Jr., M.D. (by invitation), and Andrew

G. Jessiman, M.D. (by invitation), Boston, Mass.

Discussion of Papers 1 through 9 to be opened by Harold O. Peterson, M.D., Minneapolis, Minn.

Tuesday Evening, September 22, 1959
Eight-fifteen o'clock

THE CALDWELL LECTURE

The Significance of Abnormalities of the Cervical Spine

by

Donald L. McRae, M.D.

Associate Professor of Radiology in the Department of Radiology, McGill University, Montreal, Que., Canada.

Associate Professor of Neuroradiology in the Department of Neurology and Neurosurgery, McGill University, Montreal, Que., Canada.

Introduction:

Carleton B. Peirce, M.D., F.A.C.P., F.R.C.P.&S. (Can.).

Professor of Radiology, McGill University.

Radiologist-in-Chief, Royal Victoria Hospital, Montreal, Que., Canada.

Presentation of the Caldwell Medal to Dr. McRae by President Neuhauser.

Wednesday, September 23, 1959

8:30 A.M.

Presiding: John Caffey, M.D.
New York, N. Y.

10. Radiation Accidents. Eugene L. Saenger, M.D., Cincinnati, Ohio.
11. Radiologic Diagnosis of Corrected Transposition of Great Vessels. Richard G. Lester, M.D. (by invitation), Ray C. Anderson, Ph.D., M.D. (by invitation), Kurt Amplatz, M.D. (by invitation), and Paul Adams, M.D. (by invitation), Minneapolis, Minn.
12. Virology of Giant Cell Pneumonia. Anna T. Mitus, M.D. (by invitation), Boston, Mass.
13. Radiographic Aspects of Giant Cell Pneumonia. Martin H. Wittenborg, M.D., Boston, Mass.
14. Interstitial Plasma Cell Pneumonia—A Delineation of the Disease for Radiologists with Emphasis on Radiographic Manifestations. Herbert G. Peterson, Jr., M.D. (by invitation), John L. Gwinn, M.D. (by invitation), and Robert S. Cleland, M.D. (by invitation), Los Angeles, Calif.
15. Pneumocystis Carini Pneumonia. K. H. Falkenbach, M.D. (by invitation), P. S. Mahoney, M.D. (by invitation), and B. J. O'Loughlin, M.D., Los Angeles, Calif.
16. Renal Tubular Ectasia in Cystic Disease of the Kidneys and Liver. Bernard J. Reilly, M.B., Ch.B. (by invitation), Saskatoon, Sask., Canada, and Edward B. D. Neuhauser, M.D., Boston, Mass.
17. Some Observations on Gastric Disease in Pediatric Radiology. Harvey A. Humphrey, M.D. (by invitation), St. Louis, Mo.
18. Increased Intracranial Pressure—Roentgen Studies in Infants and Children. Sidney P. Traub, M.D. (by invitation), Saskatoon, Sask., Canada.
19. An Assessment of the Value of Dehydration in the Preparation for Intravenous Pyelography. J. Scott Dunbar, M.D., Montreal, Que., Canada.

Discussion of Papers 10 through 19 to be opened by Frederic N. Silverman, M.D. (by invitation), Cincinnati, Ohio.

2:00 P.M.

Moving Picture on Radiation Hazards.

Thursday, September 24, 1959

8:30 A.M.

Presiding: Franklin B. Bogart, M.D.
Chattanooga, Tenn.

20. Rapid Automatic X-ray Film Processing. Everett L. Pirkey, M.D., Louisville, Ky.
21. A Study of Dosimetry and Some Other Physical Factors Relating to Serial and Cineradiography. Theodore E. Keats, M.D., Gwilym S. Lodwick, M.D., and George F. Koenig, R.T. (by invitation), Columbia, Mo.
22. Factors Influencing Image Quality in Cineradiography. John A. Campbell, M.D., and Eugene C. Klatte, M.D. (by invitation), Indianapolis, Ind.
23. The Use of the Cinefluorograph in the Routine Examination of the Upper Gastrointestinal Tract. (Experience in 1000 Cases.) Joseph Jorgens, M.D., Ph.D. (by invitation), Ilmar Kiesel,

M.D. (by invitation), and Harlan Hawkinson, M.D. (by invitation), Minneapolis, Minn.

24. Roentgen Manifestations of Mesenteric Vascular Disease. C. C. Wang, M.D. (by invitation), Boston, Mass., and John D. Reeves, M.D., Gainesville, Fla.
25. Serial Femoral Arteriography in Occlusive Disease: Clinical-Roentgenologic Considerations. Henry Haimovici, M.D. (by invitation), Jerome H. Shapiro, M.D. (by invitation), and Harold G. Jacobson, M.D. (by invitation), New York, N. Y.

Discussion of Papers 20 through 25 to be opened by John F. Holt, M.D., Ann Arbor, Mich.

26. Segmental Dilatation of the Colon During the Course of Fulminating Ulcerative Colitis—Roentgen Findings. Bernard S. Wolf, M.D., and Richard H. Marshak, M.D., New York, N. Y.
27. Familial Recurring Polyserositis: Clinical and Roentgen Diagnosis. William R. Eyler, M.D. (by invitation), Robert K. Nixon, Jr., M.D. (by invitation), and Robert J. Priest, M.D. (by invitation), Detroit, Mich.
28. Distended Gallbladder: The Value of a Fat Meal in Cholecystography. Maurice D. Sachs, M.D., and Philip Partington, M.D. (by invitation), Cleveland, Ohio.
29. The Big Duodenum. Harry W. Fischer, M.D. (by invitation), Iowa City, Iowa.
30. Osteoblastic Metastases in Bronchial and Intestinal Carcinoid. Frances B. Toomey, M.D. (by invitation), and Benjamin Felson, M.D., Cincinnati, Ohio.

Discussion of Papers 26 through 30 to be opened by Philip J. Hodes, M.D., Philadelphia, Pa.

Thursday Evening, September 24, 1959

6:30 Cocktails in the Caprice Suite.

7:30 The Annual Banquet in the Pavillon Caprice.

Levity and Learning in Literature. Speaker: Emmett O'Grady, B.A., Ph.D., Professor of English and Head of the English Department, University of Ottawa.

Presentation of 1959 Scientific Awards.

Friday, September 25, 1959

8:30 A.M.

Presiding: Traian Leucutia, M.D. Detroit, Mich.

31. Cobalt 60 Radiography. C. Richard Perryman, M.D., D.Sc. (Med.), and John D. McAllister, M.D. (by invitation), Pittsburgh, Pa.
32. The Design of a Second Cobalt-60 Unit Based on Experience of 1,000 Cases Treated with the First Unit. Gilbert H. Fletcher, M.D., Ernest J. Braun, M.D. (by invitation), E. B. Moore, B.S. (by invitation), and Earl Von Roosenbeek (by invitation), Houston, Texas.
33. Radiation Therapy of Benign Conditions. George Cooper, Jr., M.D., Charlottesville, Va.
34. Lymphosarcoma: Long Term Results Following Radiation Therapy. James C. Cook, M.D., Kenneth L. Krabbenhoft, M.D., Traian Leucutia, M.D., Detroit, Mich.
35. Preliminary Experience with Split-Dose or Periodic Radiotherapy. Paul W. Scanlon, M.D., Rochester, Minn.
36. Response and Recovery of Normal and Grafted Skin to Ionizing Radiation. Philip Rubin, M.D. (by invitation), Anatol Ryplansky, M.D. (by invitation), and Lester Cramer, M.D. (by invitation), Rochester, N. Y.
37. Isodose Curves about the Beds of Patients Containing Radium and/or Cobalt 60. William F. Barry, Jr., M.D. (by invitation), Durham, N. C.
38. The Effect of Triiodothyronine on Radiosensitivity. Melvin L. Griem, M.D. (by invitation), and Joseph A. Stein, M.D. (by invitation), Chicago, Ill.
39. A Critical Appraisal of the Diagnostic and Prognostic Value of Radioiron Study in Hematologic Disorders. C. T. Teng, M.D. (by invitation), Vincent P. Collins, M.D., and W. D. West, M.D. (by invitation), Houston, Texas.
40. The Use of Viable Tissue Culture of Walker Carcinoma 256 in a Study of the Relative Biological Effectiveness of Telecobalt Radiation as Compared with Orthovoltage Radiation. Damon D. Blake, M.D. (by invitation), Smith Foushee, M.D. (by invitation), Robert

Tuttle, M.D. (by invitation), Richard-L. Witcofski (by invitation), and Isadore Meschan, M.D., Winston-Salem, N. C.

41. Contribution of Plasma Constituents Produced Following Whole Body Irradiation on the Efficacy of Local Tumor Radiotherapy. Melvin R. Sikov, Ph.D. (by invitation), and James E. Lofstrom, M.D., Detroit. Mich.

SOCIETY PROCEEDINGS

MEETINGS OF RADIOLOGICAL SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. C. Allen Good, Mayo Clinic, Rochester, Minn. Annual meeting: Netherland-Hilton Hotel, Cincinnati, Ohio, Sept. 22–25, 1959.

AMERICAN RADIUM SOCIETY
Secretary, Dr. Robert L. Brown, Winship Clinic, Emory University, Atlanta 22, Ga. Annual meeting: Caribe Hilton, San Juan, Puerto Rico, March 17–19, 1960.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 713 E. Genesee St., Syracuse 2, N. Y. Annual meeting: Palmer House, Chicago, Ill., Nov. 15–20, 1959.

AMERICAN COLLEGE OF RADIOLOGY
Executive Director, William C. Stronach, 20 N. Wacker Drive, Chicago 6, Illinois. Annual meeting: Feb. 3–6, 1960, Roosevelt Hotel, New Orleans, La.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. T. Leucutia, Harper Hospital, Detroit 1, Mich. Annual meeting: June 13–17, 1960, Miami Beach, Fla.

AMERICAN BOARD OF RADIOLOGY
Secretary, Dr. H. Dabney Kerr. Correspondence should be directed to Kahler Hotel Building, Rochester, Minn. The Board will conduct a Special Examination in Nuclear Medicine (for diplomates in Radiology or Therapeutic Radiology) on Dec. 5, 1959 at the Shoreham Hotel in Washington, D. C. Deadline for filing applications is Aug. 1, 1959. The regular fall examination will be held at the Shoreham Hotel, December 6–9, 1959. Deadline for filing applications was July 1, 1959. Candidates examined in Diagnostic Roentgenology may expect to be examined in Physics.

NINTH INTERNATIONAL CONGRESS OF RADIOLOGY
Secretary-General, Dr. Hans v. Braunbehrens. Request for information should be addressed to Dr. Viktor Loeck, Kongressbüro, Forsthausstrasse 76, Frankfurt am Main, Germany. Meets in Munich, Germany, July 23 to July 30, 1959.

SEVENTH INTER-AMERICAN CONGRESS OF RADIOLOGY
Secretary, Dr. Laura Fariñas, Havana, Cuba. *Counselor for the United States*, Dr. J. A. del Regato, Penrose Cancer Hospital, 2200 North Cascade Avenue, Colorado Springs, Colorado. The meeting will be held in Brazil in 1961.

ALABAMA RADIOLOGICAL SOCIETY
Secretary, Dr. J. A. Meadows, Jr., Medical Arts Bldg., Birmingham 5, Ala. Meets time and place Alabama State Medical Association.

AMERICAN NUCLEAR SOCIETY
Executive-Secretary, Octave J. Du Temple, 86 E. Randolph St., Chicago, Ill.

ARIZONA RADIOLOGICAL SOCIETY
Secretary, Dr. R. Lee Foster, 1313 N. Second St., Phoenix, Ariz. Two regular meetings a year. Annual meeting at time and place of State Medical Association and interim meeting six months later.

ARKANSAS RADIOLOGICAL SOCIETY
Secretary, Dr. J. B. Scruggs, Arkansas Baptist Hospital, Little Rock, Ark. Meets every three months and also at time and place of State Medical Association.

ASSOCIATION OF UNIVERSITY RADIOLOGISTS
Secretary, Dr. Paul Riemenschneider, Medical College. State University of New York, Syracuse, N. Y. Annual meeting: Spring, 1959 in Atlanta, Ga.

ATLANTA RADIOLOGICAL SOCIETY
Secretary, Dr. J. L. Clements, Jr., 35 Linden Ave., N.E., Atlanta 8, Ga. Meets monthly, except during three summer months, on second Friday evening.

BLOCKLY RADIOLOGICAL SOCIETY
Secretary, Dr. Samuel Finkelman, 101 S. Twentieth St. Philadelphia, Pa.

BROOKLYN RADIOLOGICAL SOCIETY
Secretary, Dr. George A. Manfredonia, One Hanson Place, Brooklyn, N. Y. Meets first Thursday of each month October through May.

BUFFALO RADIOLOGICAL SOCIETY
Secretary, Dr. Alfred Dobrak, 710 Leydecker Rd., Buffalo 24, N. Y. Meets second Monday evening each month, October to May inclusive.

CENTRAL NEW YORK RADIOLOGICAL SOCIETY
Secretary, Dr. Joseph A. Head, 150 Marshall St., Syracuse, N. Y. Meets first Monday each month October through May.

CENTRAL OHIO RADIOLOGICAL SOCIETY
Secretary, Dr. William B. Schwartz, 1500 W. Third Ave., Columbus, Ohio. Meets at 6:30 P.M. on second Thursday of October, November, January, March and May at Fort Hayes Hotel, Columbus, Ohio.

CENTRAL SOCIETY OF NUCLEAR MEDICINE
Secretary, Dr. Robert S. Landauer, Radiation Center Building, 1903 West Harrison St., Chicago 12, Ill.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. George B. Cahill, 802 Burns Ave., Flossmoor, Ill. Meets second Thursday of each month, October to April except December at the Sheraton Hotel at 8:00 P.M.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. Frederick A. Rose, 2065 Adelbert Rd., Cleveland 6, Ohio. Meetings at 7:00 P.M. on fourth Monday of each month from October to April at Tudor Arms Hotel.

COLORADO RADIOLOGICAL SOCIETY
Secretary, Dr. Lorenz R. Wurtzebach, 601 E. Nineteenth Ave., Denver, Colo. Meets third Friday of each month at Denver Athletic Club.

CONNECTICUT VALLEY RADIOLOGIC SOCIETY
Secretary, Dr. Paul J. Kingston, 114 Woodland St., Hartford, Conn. Meets first Friday in February and April.

DALLAS-FORT WORTH RADIOLOGICAL CLUB
Secretary, Dr. A. H. Keene, 3707 Gaston Ave., Dallas, Texas. Meets monthly, third Monday, at Greater Fort Worth International Airport at 6:30 P.M.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. Kenneth L. Krabbenhoft, Harper Hospital, Detroit 1, Mich. Meets monthly first Thursday, October through May, at David Whitney House, 1010 Antietam, at 6:30 P.M.

EAST BAY ROENTGEN SOCIETY
Secretary, Dr. Dan Tucker, 434 30th St., Oakland 9, Calif. Meets first Thursday each month at Peralta Hospital, Oakland.

EAST TENNESSEE RADIOLOGICAL SOCIETY
Secretary, Dr. Charles W. Reavis, Baroness Erlanger Hospital, Chattanooga, Tenn. Meets in January and September.

*** Secretaries of societies are requested to send timely information promptly to the Editor.**

Eastern Radiological Society
Secretary, Dr. John D. Osmond, Jr., Euclid-Glenville Hospital, Cleveland 19, Ohio.

Florida Radiological Society
Secretary, Dr. Russell D. D. Hoover, 49th St., West Palm Beach, Fla. Meets twice annually, in the spring with the annual State Society meeting, and in the fall.

Florida West Coast Radiological Society
Secretary-Treasurer, Dr. Joseph C. Rush, 1501 Jungle, St. Petersburg, Fla.

Georgia Radiological Society
Secretary, Dr. B. H. Malone, 1406 Reynolds St., Brunswick, Ga. Meets Spring and Fall with Annual State Society Meeting.

Greater Miami Radiological Society
Secretary, Dr. George P. Daurelle, Jackson Memorial Hospital, Miami 36, Fla. Meets monthly third Wednesday at 8 P.M. at Jackson Memorial Hospital, Miami, Fla.

Greater St. Louis Radiological Society
Secretary, Dr. Harvey A. Humphrey, 462 N. Taylor, St. Louis 8, Mo.

Houston Radiological Society
Secretary, Dr. Edward B. Singleton, 6621 Fannin St., Houston 25, Texas. Meets last Monday each month, Seminar Room, Doctors' Club of Houston.

Idaho State Radiological Society
Secretary, Dr. Charles R. McWilliams, Magic Valley Memorial Hospital, Twin Falls, Idaho. Meets annually at same time as Idaho State Medical Association.

Illinois Radiological Society
Secretary, Dr. Stephen L. Casper, 1101 Maine St., Quincy, Ill. Meets three times a year.

Indiana Roentgen Society
Secretary, Dr. C. A. Stayton, Jr., 313 Hume-Mansur Bldg., Indianapolis 4, Ind. Meets first Sunday in May and during fall meeting of Indiana State Medical Association.

Iowa Radiological Society
Secretary, Dr. James T. McMillan, 1104 Bankers Trust Bldg., Des Moines, Iowa. Luncheon and business meeting during annual session of Iowa State Medical Society. The scientific section is held in the autumn.

Kansas Radiological Society
Secretary, Dr. Lewis G. Allen, 807 Huron Bldg., Kansas City, Kansas. Meets in spring with State Medical Society, and in winter on call.

Kentucky Radiological Society
Secretary, Dr. Robert H. Akers, V. A. Hospital, Louisville 2, Ky. Meets monthly on second Friday at Seelbach Hotel, Louisville.

Kings County Radiological Society
Secretary, Dr. C. P. Naidorf, 411 Parkside Ave. Brooklyn 26, N. Y. Meets Kings County Med. Soc. Bldg. monthly on fourth Thursday, October to May, 8:45 P.M.

Los Angeles Radiological Society
Secretary, Dr. Robert B. Engle, St. Luke Hospital, Pasadena, Calif. Meets second Wednesday of month in September, November, March, April and June at Los Angeles County Medical Association Building, Los Angeles.

Maine Radiological Society
Secretary, Dr. Francis J. O'Connor, Augusta General Hospital, Augusta, Maine. Meets in June, September, December and March.

Maryland Radiological Society
Secretary, Dr. Nathan B. Hyman, 1805 Eutaw Place, Baltimore 17, Md.

Memphis Roentgen Society
Secretary, Dr. James L. Booth, 899 Madison Ave., Memphis 3, Tenn. Meets first Monday of each month at John Gaston Hospital.

Miami Valley Radiological Society
Secretary, Dr. S. F. Johnson, 2197 Los Arrow Dr., Dayton 9, Ohio. Meets second Friday of fall and winter months.

Mid-Hudson Radiological Society
Secretary, Dr. Joseph Sorrentino, St. Francis Hospital, Poughkeepsie, N. Y. Meets 8:30 P.M., fourth Wednesday each month, September to May.

Milwaukee Roentgen Ray Society
Secretary, Dr. Joseph F. Wepfer, 5000 W. Chambers St., Milwaukee 10, Wis. Meets monthly on fourth Monday at University Club.

Minnesota Radiological Society
Secretary, Dr. Donald H. Peterson, 853 Medical Arts Bldg., Minneapolis 2, Minn. Meets three times annually, in fall, winter and spring.

Mississippi Radiological Society
Secretary, Dr. Bernard T. Hickman, University Medical Center, Jackson, Miss. Meets third Thursday of each month at Hotel Edwards, Jackson, at 6:00 P.M.

Montana Radiological Society
Secretary, Dr. Arthur T. Austin, 104 The Doctors Bldg., Billings, Montana. Meets at least once a year.

Nassau Radiological Society
Secretary, Dr. Jerome Zwanger, 126 Hicksville Rd., Massapequa, L. I., N. Y. Meets second Tuesday of the month in February, April, June, October and December.

Nebraska Radiological Society
Secretary, Dr. Warren Q. Bradley, 924 Sharp Bldg., Lincoln, Nebraska. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

New England Roentgen Ray Society
Secretary, Dr. John E. Gary, 1180 Beacon St., Brookline 46, Mass. Meets third Friday of each month, October through May, at The Longwood Towers, Brookline, Mass.

New Hampshire Roentgen Ray Society
Secretary, Dr. Paul Y. Hasserjian, 1470 Elm St., Manchester, N. H. Meets four to six times yearly.

New York Roentgen Society
Secretary, Dr. Harold G. Jacobson, 210th St. and Bainbridge Ave., New York 67, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 4:30 P.M.

North Carolina Radiological Society
Secretary, Dr. Charles A. Bream, 211 McCauley St., Chapel Hill, N. C. Meets in May and October.

North Dakota Radiological Society
Secretary, Dr. Marianne Wallis, St. Joseph's Hospital, Minot, N. D. Meetings by announcement.

North Florida Radiological Society
Secretary, Dr. Paul A. Mori, 800 Miami Road, Jacksonville 7, Fla. Meets quarterly in March, June, September and December.

Northeastern New York Radiological Society
Secretary, Dr. Irving Van Woert, Jr., Albany Hospital, Albany, N. Y. Meets in Albany area on second Wednesday of October, November, March and April.

Northern California Radiological Society
Secretary, Dr. Rob H. Kirkpatrick, 1219 28th St., Sacramento, Calif. Meets at dinner last Monday of each month, September to June.

Ohio State Radiological Society
Secretary, Dr. Francis C. Curtzwiler, 421 Michigan St., Toledo 2, Ohio. Annual meeting: Cincinnati, Ohio, May, 1959.

Oklahoma State Radiological Society
Secretary, Dr. Edmond H. Kalmon, Jr., 300 Northwest 12th Street, Oklahoma City, Okla. Three regular meetings annually.

Oregon Radiological Society
Secretary, Dr. C. V. Allen, Veterans Hospital, Portland, Ore. Meets monthly from October to June on the second Wednesday of each month at 8:00 P.M. at the University Club.

Orleans Parish Radiological Society
Secretary, Dr. Joseph V. Schlosser, Charity Hospital, New Orleans 13, La. Meets second Tuesday of each month.

Pacific Northwest Radiological Society
Secretary, Dr. J. Arch Colbrunn, 19 Royal Oak Drive, Roseburg, Ore. Annual meeting: Seattle, Wash., May 8–10, 1959.

Pacific Roentgen Society
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco 8, Calif. Meets annually during meeting of California Medical Association.

Pennsylvania Radiological Society
Secretary, Dr. Walter P. Bitner, 234 State St., Harrisburg, Pa.

Philadelphia Roentgen Ray Society
Secretary, Dr. Roderick L. Tondreau, 3400 Spruce St., Philadelphia 4, Pa. Meets first Thursday of each month, at 5 P.M., from October to May in Thompson Hall, College of Physicians.

Pittsburgh Roentgen Society
Secretary, Dr. Erwin Beck, 3500 Fifth Ave., Pittsburgh 13, Pa. Meets second Wednesday of month, October through June at Park Schenley Restaurant.

Radiological Section, Baltimore Medical Society
Secretary, Dr. James K. V. Willson, 1100 N. Charles St., Baltimore 1, Md. Meets third Tuesday each month, September to May, inclusive.

Radiological Society of Greater Cincinnati
Secretary, Dr. John E. Singer, 468 Doctors' Bldg., Cincinnati 2, Ohio. Meets monthly from September to May on first Monday of each month at 7:30 P.M. at the Cincinnati General Hospital.

Radiological Society of Hawaii
Secretary, Dr. Robert G. Rigler, Straub Clinic, 1020 Kapiolani St., Honolulu 14, Hawaii. Meets third Monday of each month alternately at 4:30 P.M. and 7:30 P.M.

Radiological Society of Greater Kansas City
Secretary, Dr. Samuel B. Chapman, Jr., 830 Argyle Bldg., Kansas City, Mo. Meets last Friday of each month.

Radiological Society of Kansas City
Secretary, Dr. Arthur B. Smith, 800 Argyle Bldg., Kansas City, Mo. Meets third Thursday of each month.

Radiological Society of Louisiana
Secretary, Dr. Seymour Ochsner, Ochsner Clinic, New Orleans 15, La. Meets annually during Louisiana State Medical Society meeting.

Radiological Society of New Jersey
Secretary, Dr. Andrew P. Dedick, Jr., 67 E. Front St., Red Bank, N. J. Meets at Atlantic City at time of State Medical Society and in November in Newark, N. J.

Radiological Society of New York State
Secretary-Treasurer, Dr Mario C. Gian, 610 Niagara St., Buffalo 1, N. Y. Annual meeting: To be announced.

Radiological Society of South Dakota
Secretary-Treasurer, Dr. Donald J. Peik, 303 S. Minnesota Ave., Sioux Falls, S. D.

Radiological Society of Southern California
Secretary, Dr. Harold P. Tompkins, 658 S. Westlake, Los Angeles 57, Calif.

Redwood Empire Radiological Society
Secretary, Dr. Lee E. Titus, 164 W. Napa St., Sonoma, Calif. Meets second Monday every other month.

Richmond County Radiological Society
Secretary, Dr. W. F. Hamilton, Jr., University Hospital, Augusta, Ga. Meets first Thursday of each month at various hospitals.

Rochester Roentgen Ray Society, Rochester, N. Y.
Secretary, Dr. Theodore F. Van Zandt, 501 W. Main St., Rochester 8, N. Y. Meets at 8:15 P.M. on the last Monday of each month, September through May, at Strong Memorial Hospital.

Rocky Mountain Radiological Society
Secretary, Dr. John H. Freed, 4200 East Ninth Ave., Denver 20, Colo. Annual meeting: Shirley-Savoy Hotel, Denver, Colorado, Aug. 20–22, 1959.

San Antonio-Military Radiological Society
Secretary, Dr. Hugo F. Elmendorf, Jr., 730 Medical Arts Bldg., San Antonio 5, Texas. Meets third Wednesday each month in Fort Sam Houston Officer's Club at 6:30 P.M.

San Diego Radiological Society
Secretary, Dr. Stanley A. Moore, 2466 First Ave., San Diego 1, Calif. Meets first Wednesday of each month at the University Club.

San Francisco Radiological Society
Secretary, Dr. M. A. Sisson, 450 Sutter St., San Francisco 8, Calif. Meets quarterly at Grison's Steak House.

Section on Radiology, California Medical Association
Secretary, Dr. William H. Graham, 630 East Santa Clara St., San Jose, Calif.

Section on Radiology, Connecticut State Medical Society
Secretary, Dr. Ralph J. Littwin, Bristol Hospital, Bristol, Conn. Meetings are held bi-monthly.

Section on Radiology, Medical Society of the District of Columbia
Secretary, Dr. Charles E. Bickham, Jr., 1835 Eye St., N.W., Washington 6, D. C. Meets Medical Society Library, third Wednesday of January, March, May and October at 8:00 P.M.

Section on Radiology, Illinois State Medical Society
Secretary, Dr. William Meszaros, 1825 W. Harrison St., Chicago, Ill.

Section on Radiology, Southern Medical Association.
Secretary, Dr. Seymour Ochsner, Ochsner Clinic, 3503 Prytania St., New Orleans 15, La. Annual meeting: Nov. 16–19, 1959, Atlanta, Ga.

Shreveport Radiological Club
Secretary, W. R. Harwell, 608 Travis St., Shreveport, La. Meets monthly on third Wednesday, at 7:30 P.M. September to May inclusive.

Society of Nuclear Medicine
Secretary, Dr. Robert W. Lackey, 452 Metropolitan Bldg., Denver 2, Colo. Annual meeting: June 18–20, 1959, Palmer House, Chicago, Ill.

South Bay Radiological Society
Secretary, Dr. Stanford B. Rossiter, 1111 University Dr., Menlo Park, Calif. Meets second Wednesday of each month.

South Carolina Radiological Society
Secretary, Dr. Wayne Reeser, 804 Burroughs St., Conway, S. C. One meeting with South Carolina Medical Association in May, others arranged by President.

Southern Radiological Conference
Secretary, Dr. Marshall Eskridge, Mobile Infirmary, Mobile, Ala.

Southwestern Radiological Society
Secretary, Dr. Gordon Black, Suite 2-A, El Paso Medical Center, 1501 Arizona, El Paso, Texas. Meets second Tuesday of each month.

Tennessee Radiological Society
Secretary, Dr. James J. Range, P.O. Box 324, Johnson City, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. R. P. O'Bannon, 402 Professional Bldg., 1216 Pennsylvania Ave., Fort Worth 4, Texas. Next meeting January 22 and 23, 1960, Houston, Texas.

Tri-State Radiological Society
Secretary, Dr. James R. Mathews, 118 S. E. First St., Evansville, Ind. Meets last Wednesday of Oct., Jan., March and May, 8:00 P.M. at Elks' Club in Evansville.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7:00 P.M. at University Hospital.

Upper Peninsula Radiological Society
Secretary, Dr. A. Gonty, Menominee, Mich. Meets quarterly.

Utah State Radiological Society
Secretary, Dr. William R. Christensen, 2033 S. State St., Salt Lake City, Utah. Meets fourth Wednesday in January, March, May, September and November at Holy Cross Hospital.

Virginia Radiological Society
Secretary, Dr. Frank A. Kearney, II, 110 S. Curry St., Phoebus, Va. Meets annually in October.

Washington State Radiological Society
Secretary, Dr. Wayne A. Chesledon, 306 Stimson Bldg., Seattle 1, Wash. Meets fourth Monday of each month from September through May at 610 Pine St., Seattle.

West Virginia Radiological Society
Secretary, Dr. Karl J. Myers, 112 N. Woods St., Philippi, W. Va. Meets concurrently with annual meeting of West Virginia State Medical Society; other meetings arranged by program committee.

Westchester Radiological Society
Secretary, Dr. Arnold Myron Wald, 406 Boston Post Road, Port Chester, N. Y. Meets on third Tuesday of January and October and on two other dates.

Wisconsin Radiological Society
Secretary, Dr. Farrell F. Golden, 5221 Tonyawatha Trail, Madison 4, Wis. Special meetings held during year; annual meeting each spring at Madison, Wis.

X-Ray Study Club of San Francisco
Secretary, Dr. John H. Heald, 450 Sutter St., San Francisco 8, Calif. Meets monthly, third Thursday at 7:30 P.M., Children's Hospital, September through June.

Cuba, Mexico, Puerto Rico and Central America

Asociación de Radiólogos de Centro America y Panamá
Comprising: Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica and Panamá, *Secretary-General*, Dr. Roberto Calderón, Calle Central Deste No. 218, Managua, Nicaragua. Meets annually in a rotating manner in the six countries.

Sociedad de Radiología de El Salvador
Secretary, Dr. Rafael Vega Gómez.

Sociedad de Radiología de Guatemala
Secretary, Dr. Carlos E. Escobar, 9ª. Calle A 0-05, Zona 1, Guatemala.

Sociedad de Radiología y Fisioterapía Cubana
Secretary, Dr. Miguel A. García Plasencia, Hospital Curie, 29 y F, Vedado, Habana, Cuba. Meets monthly at Curie Hospital.

Sociedad Costarricense de Radiologia
Secretary, Dr. James Fernández Carballo, Apartado VIII, San José, Costa Rica.

Sociedad Mexicana de Radiología, A. C.
Calle del Oro No. 15, México 7, D. F.
Secretary-General, Dr. Guillermo Santín. Meets first Monday of each month.

Asociación Puertorriqueña de Radiología
Secretary, Dr. R. B. Díaz Bonnet, Suite 504, Professional Bldg., Santurce, Puerto Rico.

Sociedad Radiológica Panameña
Secretary, Dr. L. Arrieta Sánchez, Apartado No. 86, Panamá, R. de P. Meets monthly in a department of radiology of a local hospital, chosen at preceding meeting.

British Commonwealth of Nations

Association of Radiologists of the Province of Quebec
Secretary, Dr. Odilon Raymond, 5400 Blvd. Gouin. Quest, Montreal, Que. Meets four times a year.

British Institute of Radiology Incorporated with the Röntgen Society
Honorary Secretary, Dr. John Blewett, 32 Welbeck St., London, W. 1. Meets monthly from October until May.

Faculty of Radiologists
Honorary Secretary, Dr. R. A. Kemp Harper, 47 Lincoln's Inn Fields, London, W.C.2, England. Annual meeting in London (at the Royal College of Surgeons and the Westminster Hospital), June 19–20, 1959.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets third Friday each month at 4:45 P.M. at the Royal Society of Medicine, 1 Wimpole St., London, W. 1.

Canadian Association of Radiologists
Honorary Secretary, Dr. Robert G. Fraser, *Associate Honorary Secretary*, Dr. Jean-Louis Léger, 1555 Summerhill Ave., Montreal 25, Que. Meetings January and June.

Montreal Radiological Study Club
Secretary, Douglas W. MacEwan, 2300 Tupper St., Montreal 25, Quebec. Meets first Tuesday evening, October to April.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext. Halifax, N. S. Annual meeting: July 18–25, 1959, Edinburgh.

Société Canadienne-Française d'Electro-Radiologie Médicale
General Secretary, Dr. Louis Ivan Vallée, 1058 rue St-Denis, Montreal 18, Canada. Meets third Saturday each month.

Toronto Radiological Society
Secretary, Dr. L. R. Harnick, Toronto Western Hospital, 399 Bathurst St., Toronto, Ontario. Meets second Monday of each month September through May.

College of Radiologists of Australasia
Honorary Secretary, Dr. E. A. Booth, c/o British Medical Agency, 135 Macquarie St., Sydney, N.S.W., Australia.

South America

Asociación Argentina de Radiología
Secretary, Dr. Lidio G. Mosca, Avda. Gral. Paz 151, Córdoba, Argentina. Meetings held monthly.

Ateneo de Radiologia
Secretary, Dr. Victor A. Añaños, Instituto de Radiologia, Santa Fe 3100, Rosario, Argentina. Meets monthly on second and fourth Fridays at 7:00 P.M. in the Hospital Nacional del Centenario, Santa Fe 1300, Rosario.

O Colégio Brasileiro de Radiologia
Secretary-General, Dr. Walter Bomfins Pontes. Seat: Rua Major Quedinho, 99-2°. Andar, São Paulo, Brazil.

Sociedad Argentina de Radiología, Junta Central, Buenos Aires
Secretary, Dr. Edgardo O. Olcese, Santa Fé 1171, Buenos Aires. Meetings are held monthly.

Sociedad Bolivana de Radiología
Secretary, Dr. Javier Prada Méndez, Casilla 1596, La Paz, Bolivia. Meets monthly. General assembly once every two years.

Sociedade Brasileira de Radiologia
Secretary, Dr. Nicola Caminha, Av. Mem. de Sa, Rio de Janeiro, Brazil. General Assembly meets every two years in December.

Sociedade Brasileira de Radioterapia
Secretary, Dr. Oscar Rocha von Pfuhl, Av. Brigadeiro Luiz Antonio, 644 São Paulo, Brazil. Meets monthly on second Wednesday at 9:00 P.M. in São Paulo at Av. Brigadeiro Luiz Antonio, 644.

Sociedad Chilena de Radiología
Secretary, Dr. Juan Sabbagh Dacla, Merced 565, Santiago, Chile. Meets fourth Friday of each month.

Sociedad Colombiana de Radiologia
Secretary, Dr. Alberto Mejía Diazgranados, Carrera 13, No. 25–31, Apartado aéreo No. 5804, Bogotá, Colombia. Meets last Thursday of each month.

Sociedad Ecuatoriana de Radiología y Fisioterapía
Secretary, Dr. Publio Vargas P., Casilla 1242 Guayaquil, Ecuador.

Sociedad Paraguaya de Radiología
Secretary, Dr. Miguel González Addone, 15 de Agosto 322, Asunción, Paraguay.

Sociedad Peruana de Radiologia
Secretary, Dr. Luis Pinillos Ganoza, Apartado 2306, Lima, Perú. Meets monthly except during January, February and March, at Asociación Médica Peruana "Daniel A. Carrión," Villalta 218, Lima.

Sociedad de Radiologia del Atlantico
Secretary, Dr. Raul Fernandez, Calle 40 #41-110, Baranquilla, Colombia. Society meets monthly at the Instituto de Radiologia.

Sociedad de Radiología, Cancerología y Física Médica del Uruguay
Secretary-General, Dr. Ricardo Parada, Av. Agraciada 1464, piso B, Montevideo, Uruguay.

Sociedade de Radiologia de Pernambuco
Secretary, Dr. Manoel Medeiros, Instituto de Radiologia da Faculdade de Medicina da Universidade do Recife, Caixa Postal 505, Pernambuco, Brazil.

Sociedad Venezolana de Radiología
Secretary-General, Dr. Héctor J. Rumbos, Apartado No. 9362, Caracas, Venezuela. Meets monthly third Friday at Colegio Médico del Distrito Federal, Caracas.

Continental Europe

Österreichische Röntgen-Gesellschaft
President, Dr. Konrad Weiss, Mariannengasse 10, Vienna 9, Austria. Meets second Tuesday of each month in Allgemeine Poliklinik.

Société Belge de Radiologie
General Secretary, Dr. S. Masy, 256 Chaussée de Wavre, Heverlee-lez-Louvain, Belgium. Meets in February, March, May, June, October, November and December.

Société Française d'Electroradiologie Médicale, and its branches: Société du Sud-Ouest, du Littoral Méditerranéen, du Centre et du Lyonnais, du Nord, de l'Ouest, de l'Est, et d'Alger et d'Afrique du Nord. Central Society meets third Monday of each month, except during July, August and September, rue de Seine 12, Paris.
Secretary-General, Dr. Ch. Proux, 9, rue Daru, Paris 8e, France.

Ceskoslovensk společnost pro Rëntgenologii a Radiologii v Praze
Secretary, Dr. Roman Bláha, Praha XII, stát. nemocnice, Czechoslovakia. Meets monthly except during July, August, and September. Annual general meeting.

Deutsche Röntgengesellschaft
Secretary, Professor Dr. med. H. Lossen, Universitäts-Röntgeninstitut. Lagenbeckstr. 1, Mainz, Germany. Annual meeting: To be announced.

Società Italiana di Radiologia Medica e di Medicina Nucleare
Secretary, Dr. Ettore Conte, Ospedale Mauriziano, Torino, Italy. Meets annually.

Nederlandse Vereniging voor Electrologie en Röntgenologie
Secretary, Dr. J. R. von Ronnen, Violenweg 14, den Haag, Netherlands.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association.

Sociedad Española de Radiologia y Electrologia
Secretary, Dr. D. Aureo Gutierrez Churruca, Esparteros, No. 9, Madrid, Spain. Meets monthly in Madrid.

Schweizerische Gesellschaft für Radiologie und Nuklearmedizin (Société Suisse de Radiologie et de Médecine Nucléaire)
Secretary, Dr. Max Hopf, Effingerstrasse 47, Bern, Switzerland.

India

Indian Radiological Association
Secretary, Dr. R. F. Sethna, Navsari Building, Hornby Road, Bombay 1, India.

The next list of Meetings of Radiological Societies will be published in the September issue of the Journal.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interest of our readers as space permits.

Tumors of the Lungs and Mediastinum. By B. M. Fried, M.D., F.C.C.P., Associate Attending Physician, Montefiore Hospital; Associate Visiting Physician, Morrisania City Hospital, New York, New York. Cloth. Price, $13.50. Pp. 467, with 231 black and white illustrations, 4 in color on 2 plates. Lea & Febiger, Washington Square, Philadelphia, Pennsylvania, 1958.

This is an excellent text for the student as well as for the specialist—radiologist, internist, or surgeon—interested in the diagnosis and management of tumors of the lungs and mediastinum. The major portion of the volume deals with cancer of the lung but there are excellent sections relating to bronchial adenomas; tumors of the pleura, lymphoid tissues, and thymus; terato-dermoids; and neurogenic tumors and cysts.

A distinguished group of contributing authors has joined Dr. Fried to make this a concise, yet unusually comprehensive volume. In the discussion of cancer of the lung, for example, there are chapters devoted to pulmonary function studies and the role of the pulmonary physiologist, the assessment of patients for surgery and the techniques and results of surgical treatment, and the role of radiotherapy in the management of lung cancer. The text is timely—new modalities such as supervoltage roentgen therapy and chemotherapy are discussed—and controversial issues are presented without undue bias.

Specific chapters discuss the roentgenologic diagnosis of carcinoma of the lung and tumors of the mediastinum which, though contributing little that is new, summarize clearly the proper use of available techniques and the interpretation of roentgen findings.

The volume is adequately, though not lavishly, illustrated and has a pleasing format. It is highly recommended as a concise, readable and authoritative text and reference book.

William J. Tuddenham, M.D.

Handbuch der Tuberkulose. Volume I. Allgemeine Grundlagen. Edited by Prof. Dr. J. Hein, Tönsheide; Prof. Dr. Dr. h. c. H. Kleinschmidt, Hoffen; and Prof. Dr. E Uehlinger, Zürich. Cloth. Price, DM 178.-. Pp. 832, with 244 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1958.

In general radiologic practice, the amount of "chest work" varies between 30 and 40 per cent of the total number of examinations. In the not too distant past, acid fast infection was either present, or had to be ruled out, in more than half of the cases with pulmonary pathology. Since then, tuberculosis mortality showed a spectacular decline, followed somewhat later by a similar decline in tuberculosis morbidity. In this country, outside of metropolitan centers or Indian reservations, the average radiologist finds fresh tuberculous infiltration as seldom as osteomyelitis in children, or new mastoiditis. Under these circumstances, the ambitious program in five volumes of Hein-Kleinschmidt-Uehlinger's *Handbuch der Tuberkulose* cannot fail to evoke a feeling of nostalgia. Its first volume contains 'generalities,' the fourth (about to be published) brings 'extrapulmonary hematogenous localizations,' the second will include 'clinical problems,' the third 'surgical treatment,' and the fifth shall conclude with 'social items' (surveys, follow-up, vaccination, etc.)

In the first volume of the *Handbuch* there are comparatively few things of immediate interest to the practicing radiologist. As a guide for prospective readers, it may be said that outstanding chapters are the 'history' (by Löffler of Zürich, renowned for his eponymic infiltrate), the excellent 'biology of M. tuberculosis' and 'experimental bio-immunology' (by H. Bloch of Pittsburgh and E. Suter of Gainesville, Fla.), the clear 'epidemiology and statistics' (by Redeker), the 'sources and spread of infection' (by another "old" master, Hedvall of Uppsala, Sweden), the 'constitutional factors' (by Diehl, the expert in research on identical twins), and the extensively documented 'ecological factors' and 'age and sex' (by Ott).

Unless a very firm editorial policy is enforced, a certain amount of duplication cannot be avoided. Besides, it is always easier to decide what to accept than what to delete. One might

for instance question the wisdom of having included the article on 'sero-diagnosis of tuberculosis,' a procedure which never really graduated from the experimenter's workbench. On the credit side of the book are the satisfactory bibliographies appended to each chapter, and the fact that the selection of authors has been well done, most of them being truly representative in their chosen fields. Nevertheless, the volume conveys an atmosphere of obsolescence, not so much with respect to the facts presented, as to the spirit in which it was conceived. But if it may not seem entirely adequate today, the excellent shape of this *Handbuch* (both in- and outside) makes for a very decorative presence on any respectable bookshelf. Furthermore, however outdated at publication, it will eventually become a valuable historical reference book, because it offers an excellent cross-section of yesteryear's knowledge of, and thinking on, tuberculosis.

E. R. N. Grigg, M.D.

Ergebnisse der Gesamten Tuberkulose- und Lungenforschung. Volume XIV. Edited by St. Engel, London; L. Heilmeyer, Freiburg, i. Br.; J. Hein, Tönsheide; and E. Uehlinger, Zürich. Cloth. Price, DM 144.-. Pp. 735, with 283 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1958.

This volume of the well-established *Ergebnisse* purports a refreshing feeling of actuality. It brings twelve monographs (of 60–130 pages), each of them too long for publication in a journal, but too short to fill a single book. There is an avowed intention to keep up with the times, even the traditional title has been changed to introduce the word *Lungen*. This is fairly common among "modern" phthisiologists—not too long ago, the *American Review of Tuberculosis* has added to its title and *Pulmonary Diseases*. In the preface to this fourteenth volume of the *Ergebnisse* (it first appeared in 1930, while the present one is the fourth published since World War II), the editors state openly that an increasing amount of space shall be forthwith devoted to pulmonary problems of nontuberculous origin. The present volume—which deals mostly, but not exclusively, with pulmonary circulation—is dedicated to Professor Stefan Engel (on his eightieth birthday), the only one among the current editors who was also one of its founders. In 1936, Engel (the pediatrician co-author with von Pirquet of the famous textbook on childhood tuberculosis, published in 1929–30) went into self-imposed exile to England, apparently for political reasons.

The first monograph is Engel's contribution 'to the comparative anatomy of respiratory tissues in man and mammals' (pp. 1–58), in which he shows that human pulmonary acini (respiratory units) are much larger than those of any animals, even ox and elephant, presumably because of man's erect posture. Günther Künn's text on 'morpho-pathology of pulmonary vessels and its relationship with chronic pulmonary hypertension' (pp. 101–190) may not be the easiest to comprehend, but this could be due to the controversial aspects of the subject; he compensates for all other of this chapter's shortcomings by an extensive bibliography. Just as thorough is the literary review in Esch and Grosse-Brockhoff's 'tuberculosis and circulation' (pp. 207–346), which contains a very valuable section on 'cor pulmonale' (pp. 281–313). In 'atelectases during childhood' (pp. 389–480), Görgenyi-Göttche and Kassay—after using and abusing the term "epituberculosis"—recommend strongly the resection of "irreversible" lesions. Conversely, in 'results of resection as compared with collapse procedures' (pp. 577–602), based on 3,000 instances of pulmonary resection (of which 1,800 in tuberculous patients) Adelberger and Schindler warn against any but the most compelling indications for resection in children, because of the ultimate (though so far incompletely assessed) hazards of overexpansion of the lung stump. Honorable mentions deserve the thorough review of 'sarcoidosis' (pp. 603–650) by Fresen, and the 'differential diagnosis of mediastinal pathology during infancy' (pp. 481–536) by Kirchhoff.

As a forum of expression for current research in pulmonary diseases, the *Ergebnisse* fulfill a valid scope, and the editors should be encouraged to continue this publication, perhaps with added emphasis on the review type of article to show the stage reached by a given problem, and its practical implications. From this viewpoint, those interested in pulmonary circulation can make a comparison of the opinions of German authors with the presentation of Peter Kerley (of London) on his recent visit to this country. Incidentally, Kerley is never mentioned in the fourteenth volume of *Ergebnisse*.

E. R. N. Grigg, M.D.

Medizinische Röntgentechnik. II. Physikalisch-technischer Teil. Edited by Prof. Dr. Herbert Schoen, Karlsruhe. Second edition. Cloth. Price, DM 48.—. Pp. 463, with 281 illustrations. Georg Thieme, Herdweg 63, Stuttgart, Germany, 1958.

Parts of the original edition of this book, published in 1952, left much to be desired, notably in the fields of natural and artificial radioactivity, measuring instruments for ionizing radiations, protection measures and reference literature. In the new edition, practically all of these subjects have been successfully brought up to date, although the chapter on protection again begins to look obsolete due to the rapid advances made recently in this field. The chapters on measuring instruments and dosimetry have been increased from about 5 pages in the original edition to over 60; and a new excellent chapter on properties of high energy quantum and corpuscular radiations has been added. The chapter, "Roentgenphotography," written by Loeck, is practically unchanged, although the interesting section on color photography has been omitted.

The book is beautifully printed and lavishly illustrated. In its present form this comprehensive treatise on the foundations of radiation diagnosis and therapy can be highly recommended.

Otto Glasser, Ph.D.

The Scandinavian Journal of Clinical & Laboratory Investigation. Vol. 10—Supplementum 35. The Dye Injection Method for Circulatory Studies. A Critical Evaluation of the Technique, Apparatus and Results. By Walter Falholt. Paper. Pp. 107. Christtreus Bogtrykkeri, København, Denmark, 1958.

Among the wet dilution methods for determining blood volume flow inclusive of cardiac output, blue dye injection has been thoroughly investigated and used extensively in clinics of many countries. This timely review article summarizes several techniques and results. It fails to mention the successful use at the Mayo Clinic of green dye, which has a wave length spectrum different from that of reduced hemoglobin.

Stewart's original proposal did not limit itself to conductometric study of flow following injection of electrolytes only. In the opinion of the reviewer, the dye methods do not override the important contributions of Stewart, White, Wiggers, Holt, Goodwin and Sapirstein who employed electrical conductometric principles. Conclusive studies further indicate that the absolute electrical resistive characteristics may also define flow of blood. Dyes have an inherent advantage in being thermostabile; whereas electrolytes are thermal dependent.

The incomplete bibliography on dilution methods fails to quote the titles of the articles and, therefore, minimizes the value of the review.

Jan Nybor, M.D.

BOOKS RECEIVED

Treatment of Cancer and Allied Diseases. Second edition. Volume III. Tumors of the Head and Neck. By Seventy Authors. Edited by George T. Pack, M.D., F.A.C.S., Attending Surgeon, Memorial Center for Cancer and Allied Diseases; Associate Professor of Clinical Surgery, Cornell University Medical College; Surgeon, Pack Medical Group, New York, New York, and Irving M. Ariel, M.D., F.A.C.S., Associate Clinical Professor of Surgery and Associate Attending Surgeon, New York Medical College, Flower and Fifth Avenue Hospitals; Surgeon, Pack Medical Group, New York, New York. Cloth. Price, $30.00. Pp. 781, with 1028 illustrations. Paul B. Hoeber, Inc., Medical Book Department of Harper & Brothers, 49 East 33rd Street, New York 16, N. Y., 1959.

Protection in Diagnostic Radiology. Edited by B. P. Sonnenblick, Professor of Biology, Newark College of Arts and Sciences, Rutgers University, Newark, New Jersey. Cloth. Price, $7.50. Pp. 346, with numerous tables. Rutgers University Press, New Brunswick, New Jersey, 1959.

Manual of Chest Clinic Practice in Tropical and Sub-Tropical Countries. By A. J. Benatt, M.D., Late Senior Advisor to the World Health Organization. Cloth. Price, $3.00. Pp. 100. E. & S. Livingstone Ltd., Edinburgh and London; Williams & Wilkins Co., Baltimore, exclusive U. S. agents, 1959.

Annual Review of Medicine. Volume 10. Edited by David A. Rytand, M.D., Stanford University School of Medicine; and Associate Editor William P. Creger, M.D., Stanford University School of Medicine. Cloth. Price, $7.00. Pp. 448. Annual Reviews, Inc., Grant Avenue, Palo Alto, California, 1959.

Therapie mit Röntgenstrahlen und radioaktiven Stoffen. By Dr. H.-J. Fiebelkorn, Oberarzt am Universitäts-Strahleninstitut Marburg/Lahn (Dir: Prof. Dr. R. du Mesnil de Rochemont), jetzt Chefarzt der Abteilung für Röntgendiagnostik und Strahlentherapie am Stadtkranken-

haus Rüsselsheim/Main, and Prof. Dr. W. Minder, Professor für medizinische Strahlenphysik an der Universität Bern, Leiter des Radium-Institutes. Cloth. Price, DM 43.—. Pp. 434, with numerous illustrations. Verlag Hans Huber, Bern; Intercontinental Medical Book Corporation, 381 Fourth Avenue, New York 16, N. Y., exclusive U. S. agents, 1959.

Radiation Biology and Cancer. A Collection of Papers Presented at the Twelfth Annual Symposium on Fundamental Cancer Research at The University of Texas M.D. Anderson Hospital and Tumor Institute. Edited by the Staff of The University of Texas M. D. Anderson Hospital and Tumor Institute. Cloth. Price, $8.50. Pp. 493, with numerous illustrations. The University of Texas Press, Austin 12, Texas, 1959.

Lehrbuch der Strahlenheilkunde: Behandlung mit Röntgenstrahlen und radioaktiven Substanzen. By Prof. Dr. med René du Mesnil de Rochemont, Direktor der Strahlenklinik und -Poliklinik der Universität Marburg. Unter Mitarbeit der Oberärzte der Klinik Dr. H. J. Fiebelkorn, Prof. Dr. Dr. E. H. Graul und Doz. Dr. E. Scherer. Cloth. Price, DM 119.—. Pp. 763, with numerous illustrations. Ferdinand Enke Verlag (14a), Hasenbergsteige 3, Stuttgart-W, Germany, 1958.

The Upper Atmosphere. By H. S. W. Massey, Ph.D., D.Sc., F.R.S., Quain Professor of Physics, University College, London, and R. L. F. Boyd, Ph.D., Lecturer in Physics, University College, London. Cloth. Price, $17.50. Pp. 333, with numerous illustrations. Philosophical Library, Inc., 15 East 40th Street, New York 16, N. Y., 1959.

Contact Activation in the Intrinsic Blood Clotting System. Volume XI—Supplementum 37. The Scandinavian Journal of Clinical & Laboratory Investigation: By Bjarne A. Waaler. Paper. Pp. 133, with numerous tables. Oslo University Press, Oslo, Norway, 1959.

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ABSTRACTS OF RADIOLOGICAL LITERATURE

Department Editor: T. Leucutia, M.D., Harper Hospital, Detroit 1, Michigan

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ROENTGEN DIAGNOSIS

Head

Nettl, S., Steinhart, L., Dítě, B., and Kroó, M. Unsere Erfahrungen mit der diagnostischen Ausnutzung des tiefen Phlebogramms bei intrakraniellen raumbeengenden Prozessen. (Our experiences with the diagnostic exploitation of the deep phlebogram in intracranial expansive lesions.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Dec., 1958, *89*, 645–658. (From: Nervenklinik und radiologische Klinik der Militärmedizinischen Akademie J. Ev. Purkyně, Hradec Králové und Militärkrankenhaus Jaroměř und neurochirurgische Klinik der MMA J. Ev. P., Czechoslovakia.)

For the understanding of this article, the study of the roentgenograms, tables and drawings of the original article appears irremissible.

The authors discuss one group of 100 patients with a normal deep phlebogram and another group of 100 patients with expansive intracranial lesions, with the following results.

(1) In 90 per cent the phlebogram permitted the correct localization of the tumor, even with the lateral projection alone and without the arteriogram. In 14 cases the phlebogram was of greater value than the arteriogram; in 25 cases it was equivalent.

(2) The significance of the angulus venosus (A.v.), *i.e.*, the confluence of the thalamostriate vein and the internal cerebral vein, which normally demonstrates the localization of the upper posterior margin of the foramen of Monro, was investigated. The A.v. was most significantly displaced, namely posteriorly, in cases of frontal tumors; in other localizations sometimes in the direction of the pressure effect of the tumor. Sometimes the findings were negative. The authors' method of measuring the distance of the A.v. from the sellar tubercle was of equal value with the other methods. They had good results with the measurement of the following distance from the midpoint of the arcus of the internal cerebral vein to the confluence of the ampulla Galeni with the sinus rectus. This distance was greater in posterior parietal and parieto-occipital tumors and smaller in frontal tumors.

(3) In sagittal (anteroposterior and posteroanterior) projection some details, not evaluated before, are discussed, *e.g.*, the sign of expansion on a roentgenogram with rotation, the medial displacement of the insular part of the vena Rosenthali and the sign of the segregation of the inferior sagittal sinus. Generally the authors believe that, for demonstration of an expansive tumor, the sagittal phlebogram may be more significant than the sagittal arteriogram.

(4) The superficial phlebogram may support the topical diagnosis.—*Hans Lewin, M.D.*

Schölzel, P. Fehler und Gefahren der zerebralen Angiographie und ihre Verhütung. (Errors and dangers of cerebral angiography and their prevention.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Dec., 1958, *79*, 659–670. (Address: Strahleninstitut der Universität, Homburg/Saar, Germany.)

The first part of this report deals with the complications of cerebral arteriography caused by faulty technique of the arterial puncture. According to the literature there are 3 to 10 per cent complications and a 0.2 to 0.35 per cent mortality.

To avoid any harmful effects, the author recommends puncture of the common carotid artery below the bifurcation and the larynx. Three illustrations show the correct position of the needle and the right direction, which is obliquely upward. If the needle enters at a right angle to the artery, there exists the danger of perforation or damage of the opposite wall. Besides, an oblique perforation of the arterial wall provides protection against leakage and secondary hematoma. Other comparatively rare complications are dissection of the artery by intramural injection, with the formation of pseudoaneurysms, lesions of the nerve plexus, mediastinal emphysema, spasm and edema of the larynx, osteomyelitis of the fifth cervical vertebra and paresis of the vocal cord.

The harmful side effects caused by the contrast medium are more numerous and more serious than the local lesions caused by the puncture. They are generally believed to be allergic reactions although some authors assume a reflex mechanism as the provoking factor. The author emphasizes the unreliability of the usual tests, the performance of which is justified only for medicolegal reasons.

Some of the general reactions may be due to the osmotic pressure of the contrast medium.

Within the group of contrast material reactions, one has to separate the local damages and their sequelae from the general effects discussed above. The former are primarily hemipareses and hemiplegias with motor and sensory defects, illusions, seizures and visual disturbances. Although these affections are generally reversible, they may be irreparable. These reactions are caused by mechanical effects—too high pressure on injection—and by toxic chemical effects of the contrast medium upon the arterial wall. The toxic effect is greatest at the site of the injection and in the kidneys. Kidney damage takes place when the blood concentration of the contrast medium is higher than 10 to 17.5 per cent.

Complications from the site of the central nervous system have been explained by damage of the arterial endothelium and change of vascular permeability with ensuing cerebral edema and small hemorrhages. Another factor is the vascular reaction to the contrast medium which leads to a slow-down or even a complete stop of the blood flow. Several other reac-

tions can be explained by vasospasm or vasoconstriction. Under conditions of normal cerebral circulation, the danger of spasm does not appear too serious. In pathologic vessels the stagnation of the blood stream can lead to thrombus formation. For prevention, procain injection after the contrast examination is finished is advised.

A contrast material concentration of not more than 35 per cent, which showed the smallest number of complications, is therefore recommended.

Some authors observed, in animal experiments, harmful effects even with low concentrations of the medium, if the interval between injections was short. The interval between injections should not be less than fifteen minutes.

Another recommendation is the avoidance of injecting more than 40 cc. in a single examination. The author found by experience that in the single examination an injection of 7 to 8 cc. of the contrast medium is sufficient for good visualization of the blood vessels, in the arterial as well as in the venous phase.

The author prefers local anesthesia and believes that general anesthesia should be used only on special types of patients, who are too excited to relax during the examination. Other authors recommend general anesthesia since it depresses the cerebral regulations and prevents vascular spasm with its danger of a rise of intracranial pressure. The author has never observed the harmful effects upon the visual apparatus which were reported in other publications.

Although other investigators, in a large number of examinations of 1,675 cases, did not find any relationship of the number of complications with age, disease and general condition of the patient, there seems to be a higher risk in patients between fifty and seventy years of age due to the possibility of thrombus formation. The risk of complications appears also higher after cerebral hemorrhage and trauma. In these cases a waiting period of at least ten days is recommended if one does not refrain completely from the examination.—*Hans Lewin, M.D.*

Tarnow, G. Über vorübergehende funktionelle Durchflussverzögerungen im Karotis-und Vertebralisangiogramm. (Transient functional retardation of blood flow in the carotid and the vertebral angiogram.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Dec., 1958, *89*, 671–681. (Address: Humperdinckstr. 22, Frankfurt/Main, Germany.)

Modern angiography, in addition to visualization of the vascular structure, aims to demonstrate the functional element of the blood circulation. This "functional angiography" has been proved to be important in the diagnosis of cerebral vascular diseases, and especially of vascular obstructions with their collateral circulation. In some angiograms, transient circulatory retardations have been found, sometimes with demonstrable narrowing of the vascular lumen. Several investigators, physiologists, clinicians and roentgenologists deny the theory of angiospasms, postulating that the tonus of the cerebral vessels is independent of nervous stimuli. Some neurologists and neuroradiologists believe that the angiospasms reported by other investigators represent artifacts and technical errors.

The author performed his examinations with a serialograph by Schönander, which permits up to 6 exposures in a second. Based on the angiographic appearance, he differentiates the 2 following groups of functional circulatory retardations: (1) Those of the greater arteries at the skull base and in the neck, caused by artifacts; and (2) those of single cerebral arteries, without recognizable artifact.

In the first group he describes circulatory disturbances which undoubtedly were caused by a faulty needle position or by fast injection under a high pressure. In both events the carotid or vertebral artery responds with a contraction. This may lead to a "Phasenüberschneidung" (overlapping phase), *i.e.*, visualization of the cerebral veins before the arteries have emptied completely. This functional disturbance has to be differentiated from the "early" filling of the veins as observed in tumor cases and arteriovenous angiomata. In spite of these findings of artificially caused spasms, the author believes in the existence of arterial spasms caused by sympathetic irritation, as reported by other authors in cases of severe neck trauma and cervical migraine.

In the second group the author describes isolated circulatory retardations, especially of the medial cerebral artery without any recognizable artifacts. In most of these cases an organic vascular disease, *e.g.*, arteriosclerosis or Winiwarter-Buerger's disease, was observed.

The author's theory of the possibility of spasm of the *arterioles* is sustained by the fact that he found in one case a normal blood flow on the *second* injection, and that in another case of retardation, the autopsy failed to show any pathology of the cerebral arterial system or of the cerebral tissue (tumor metastases had been suspected).—*Hans Lewin, M.D.*

Balkissoon, Basdeo, Johnson, John B., Barber, Jesse B., and Greene, Clarence S. Cerebral arteriography—diagnostic value in cerebrovascular disease. *J.A.M.A.*, Feb. 14, 1959, *169*, 676–682. (Address: J. B. Johnson, Howard University, Fifth and W Streets, N. W., Washington 1, D. C.)

The value of the diagnostic information obtainable by cerebral arteriography in the past has been offset by the danger of complications. The procedure has now been made simpler and safer by the use of a 60 per cent solution of sodium methylglucamine diatrizoate as the contrast medium, 10 ml. being injected into the common carotid artery under local

anesthesia. Roentgenograms of the cranium are made at one-second intervals for eight seconds after the injection. This procedure was carried out 80 times in 56 patients.

Cerebral arteriography has a diagnostic value in patients with congenital arteriovenous malformations, subdural hematomas, brain tumors, cerebral aneurysms, and cerebral thrombosis.

Eight case histories illustrate the importance of the data so obtained in discovering the cause and deciding on the treatment of obscure symptoms. The most impressive results were in patients with arteriovenous malformations. Undesired side-effects, ranging from transient paresis of one arm to transient hemiparesis lasting up to two days, occurred in 7 of the first 28 patients.

A review of the procedure showed that intracarotid injection of saline solution was the part which came under question: patency of the arterial needle was maintained by continuous injection of isotonic sodium chloride solution or 5 per cent glucose in water. During these initial studies, saline solution was also used to dilute the 76 per cent renografin to 60 per cent. Volumes varying from 10 to 15 ml. of renografin were employed for the injection dose.

The procedure was subsequently modified to eliminate injection of saline solution into the carotid artery, and the stylet was inserted into the Cournand needle when the needle was not in use. The injection dose volume was reduced to 10 ml. for each series of exposures, and only undiluted 60 per cent renografin was employed. Since the introduction of these modifications, reactions were uncommon and of minor degree.

No significant reactions occurred in the last 52 cases. The safety and simplicity of percutaneous cerebral arteriography performed under local anesthesia, as illustrated in this study, suggest a wider usefulness of this diagnostic method in the clarification of clinical problems involving cerebrovascular lesions.—*William C. MacCarty, Jr., M.D.*

Greenwald, C. M., Eugenio, M., Hughes, C. R., and Gardner, W. James. The importance of the air shadow of the cisterna magna in encephalographic diagnosis. *Radiology*, Nov., 1958, *71*, 695–701. (Address: W. James Gardner, Cleveland Clinic, 2020 East 93rd St., Cleveland 6, Ohio.)

The authors reviewed the pneumoencephalograms of 306 patients which were made during the year 1956 at the Cleveland Clinic Hospital. In 15 of these, the roentgen study led to the surgical exposure of the posterior fossa and in 10 the cisterna magna shadow was abnormal, either establishing the diagnosis or aiding materially in arriving at it. Five of the patients had tumors in the posterior fossa, 1 had a spontaneous cerebellar hematoma, and 1 had a meningioma at the foramen magnum. Varying expressions of embryonal atresia of the fourth ventricle were found in 7.

The importance of adequate facilities and proper precautions in the performance of pneumoencephalography, particularly in suspected cases of tumor, are stressed by the authors.—*Donald N. Dysart, M.D.*

Lombardi, G., and Larini, G. P. Osteomas of the skull. *J. Canad. A. Radiologists*, Dec., 1958, *10*, 64–65. (From: Istituto Neurologico, Milan, Italy, and Herbert Reddy Memorial Hospital, Montreal, Quebec, Canada.)

The incidence of osteomas is about 1 per cent of all cranial and intracranial neoplasms. The frontoethmoid and orbitoethmoid sinuses are the most common locations. These osteomas are usually asymptomatic and require no treatment unless for cosmetic reasons.

Of the 10 cases of osteoma reported, 6 are of the ivory type. These arise from the surface of the bone, have sharply defined borders, are round or oval in shape and have markedly increased density. Surrounding the osteomas, there is usually no area of increased vascularity and no alteration in the size of the vascular grooves. Four cases are of the spongy type. These are situated in the diploë and may attain a very large size. They are well defined and cause thinning of both inner and outer tables. They exhibit a regularly uniform diploic pattern. One unusual case showed two arterial grooves converging toward the neoplasm.—*David Morse, Jr., M.D.*

Neck and Chest

Reed, Edsel S., Wells, Paul O., and Wicker, Eugene H. Coal miners' pneumoconiosis. *Radiology*, Nov., 1958, *71*, 661–673. (Address: E. S. Reed, Harlan Memorial Hospital, Harlan, Ky.)

The authors report a series of 556 cases of coal miners' pneumoconiosis recently observed over a twenty-one month period. Six cases with accompanying roentgenograms are presented in detail.

Coal miners' pneumoconiosis is a type of pulmonary fibrosis in which the prolonged inhalation of coal dust is strongly indicated as the primary etiologic factor. Although classical silicosis occurs in a small percentage of soft-coal miners, these cases are principally confined to miners exposed to rock drilling or sand dust. The pneumoconiosis may be simple or complicated. In simple pneumoconiosis the coal dust is distributed throughout the lungs, principally around the terminal bronchioles, producing discrete nodules with minimal fibrosis. Here, however, the fibrosis has a radial disposition with an irregular border as contrasted to classical silicosis which presents a concentric arrangement of collagen with a sharp spherical outline. A distinctive type of emphysema,

"focal emphysema," occurs around the nodules of simple pneumoconiosis. These may become confluent to form bullae. When the previously described nodules coalesce to form larger masses, a stage of progressive massive fibrosis develops which is designated as complicated pneumoconiosis. This is a progressive condition regardless of continued exposure to dust, which is in contrast to the reported absence of progression in simple pneumoconiosis if coal dust exposure is discontinued. The responsible factor in progressive massive fibrosis is unknown but is thought to be superimposed infection, usually tuberculosis.

The roentgenologic diagnosis of pneumoconiosis is based on characteristic nodular opacities in the lungs, together with a history of prolonged exposure to coal dust. The characteristic pulmonary opacities are minute nodules, from 0.5 to 3.0 mm. in diameter, which often appear in clumps. Fine linear opacities frequently connect adjacent nodules into chains which enclose small translucent areas of emphysema. In the early stages this process is confined to the medial two-thirds of the lung fields. The findings in complicated pneumoconiosis are coalescent opacities superimposed on the characteristic nodular lesions of simple pneumoconiosis. Sometimes the differentiation from silicosis may be impossible but in general the lesions of silicosis develop more rapidly and the "egg-shell calcification" of the hilar lymph nodes which is occasionally seen with silicosis has rarely been observed in coal miners' pneumoconiosis. During this study one case was encountered which presented numerous large nodular shadows in the lungs in association with rheumatoid arthritis of the peripheral joints, as described by Kaplan. All chest roentgenograms were classified according to the International Conference of Pneumoconiosis. The similarity between this classification and that of the Pneumoconiosis Research Unit of South Wales is presented.

The importance of wider recognition of this disease is emphasized by the fact that it is asymptomatic in the early stages and detectable only on a chest roentgenogram. In the late stage it produces irreversible pulmonary disability.—*Edward B. Best, M.D.*

Wholey, Mark H., Good, C. Allen, and McDonald, John R. Disseminated indeterminate pulmonary disease; value of lung biopsy. *Radiology*, Nov., 1958, *71*, 651–660. (Address: The Mayo Clinic, Rochester, Minn.)

With the growing recognition of the many entities producing a roentgenologic appearance of disseminated pulmonary disease has come the realization that the information gained from the clinical history, the physical examination, and the routinely available laboratory procedures is often insufficient to provide a definite diagnosis. Surgical procedures designed to obtain tissue for histologic, bacteriologic, and chemical examination have been employed, including bronchoscopic biopsy, biopsy of the scalene group of lymph nodes, and direct biopsy of the lung. Biopsy of the lung is seldom used unless all other means have failed to provide a diagnosis; however, in a limited number of cases only biopsy of the lung can provide a definite diagnosis which is useful in planning treatment, in determining prognosis, and in solving the medicolegal problems of patients subjected to occupational hazards.

At the Mayo Clinic during a six year period biopsy of the lung was performed in 34 cases of disseminated pulmonary disease of unknown etiology. Cultures for bacteria, fungi, and viruses, and chemical analyses were done when indicated in addition to histologic examinations. The 34 cases were classified into 4 groups as follows: Group 1, idiopathic diffuse interstitial fibrosis; Group 2, granulomatosis; Group 3, neoplasm; and Group 4, chronic pneumonitis, nonspecific.

Group 1, idiopathic diffuse interstitial fibrosis, consisted of 9 cases. The roentgenologic appearance of this condition was most often confused with that of pneumoconiosis, azotemic pneumonitis, and sarcoidosis. The roentgen features as demonstrated by these cases are: (a) Both lungs are diffusely involved. Early the changes are located centrally and later extend to the periphery and the basilar regions, sparing the apices in most instances. (b) Hilar lymph adenopathy and significant pleural reactions are absent. (c) Fibrosis is present, changing in some to one showing small or miliary nodules, first as a fine reticular pattern and later as confluent shadows, especially in the bases. (d) Emphysema becomes more marked as the disease progresses. (e) Cor pulmonale was present in only 2 of the 9 cases and was associated with extensive involvement of the parenchyma of the lungs. All 9 cases satisfied the histologic criteria of Hamman and Rich; however, in several instances the clinical course was much more prolonged, for example one patient is still living twelve years after the first symptoms. It is felt that there are both acute and chronic forms of the disease. The second group composed of granulomatous diseases included 5 cases of sarcoidosis, 2 of tuberculosis, and 3 of fungus infection. In each instance the roentgen appearance was one of diffuse involvement of both lungs, with regions of confluent and linear fibrosis, sometimes with a tendency toward nodularity and associated with patches of pneumonitis. Three cases of histiocytosis were also included in the group of granulomatous diseases, and although the honeycomb pattern noted in conventional thoracic roentgenograms is not pathognomonic of histiocytosis, it appeared with such uniformity and distinction that it is felt that its presence should suggest that diagnosis as a first consideration. One case of Wegener's granulomatosis was included in this group. The neoplastic group contained 1 alveolar-cell carcinoma of the lung, 1 primary bronchogenic carcinoma, and 3

cases of metastatic carcinoma, including 1 case of chorio-adenoma destruens metastatic to the lung. Group 4, the chronic pneumonitis group, was composed of 2 cases of disseminated focal pneumonitis that resembled nodular metastatic neoplasm and 4 cases which showed extensive interstitial pneumonitis.—*Walter H. Jarvis, Jr., M.D.*

Schmutzer, Karl J., and Linde, Leonard M. Situs inversus totalis associated with complex cardiovascular anomalies. *Am. Heart J.*, Nov., 1958, *56*, 761–768. (From: The Departments of Surgery and Pediatrics, University of California Medical Center, Los Angeles, Calif.)

The incidence of situs inversus has been estimated as only 1 in 10,000. The frequency of associated cardiovascular defects is approximately 8 per cent compared to isolated dextrocardia with a 25 per cent incidence of cardiac anomalies.

The authors report 2 cases of situs inversus totalis complicated by complex cardiovascular anomalies. In Case 1 this consisted of an anteriorly located aorta and systemic ventricle, ventricular septal defect, pulmonic stenosis and partial anomalous venous drainage. In Case II a ventricular septal defect and an absent inferior vena cava with functional replacement by the azygos vein were diagnosed.

The embryologic aspects and the various cardiac anomalies associated with situs inversus totalis are discussed.—*E. C. Klatte, M.D.*

Gamna, G., Dughera, L., Quaglia, C., and Jona, E. Evaluation clinique et instrumentale de la sténose mitrale et aortique associées. (Clinical and instrumental evaluation of combined mitral and aortic stenosis.) *Presse méd.*, Oct. 29, 1958, *66*, 1693–1696. (From: Istituto di Patologia Speciale Medica, Centro di Cardiochirurgia "A. Blalock" della Clinica Chirurgica, and Istituto di Radiologia della Università, Torino, Italy.)

Aortic valvular disease is associated with mitral lesions in about 30 per cent of the cases. Recent surgical opinion admits the possibility of proceeding with a controlled mitral commisurotomy in the presence of aortic stenosis or insufficiency of moderate degree, while it is contraindicated when the aortic stenosis is marked, unless simultaneous intervention is performed on both valves.

Thirty cases were studied, all in a phase of moderate cardiac compensation. The history usually gives indication of a rheumatic etiology; however, the presence of a combined mitral and aortic stenosis is almost alone proof of this. Clinically, the history is that of the mitral lesion with strain on the pulmonary circulation. When there is angina at rest and following effort as well as fainting, one can be almost certain of a concomitant aortic stenosis. In these cases, the aortic lesion is apt to be severe and preponderant over the mitral lesion.

The first suspicion of the existence of an aortic stenosis in addition to mitral disease is the finding of a systolic murmur over the aortic area. The murmur may be loud, radiating to the vessels of the neck and over the precordium. When the mitral murmurs mask this finding, phonocardiograms are useful. The mitral disease is always evident. As tracings are made moving toward the aortic area, in most cases the systolic murmur becomes diamond-shaped with a higher frequency. The murmur is intensified in the decubitus position on the left and right sides. An esophageal microphone may demonstrate the typical murmurs more definitely. It is noted particularly that (1) right axis deviation with typical signs of left ventricular hypertrophy in the precordial leads is found practically only in combined mitral and aortic lesions, (2) in the presence of a predominant aortic stenosis, right axis deviation, mitral P waves or auricular fibrillation indicate an associated mitral stenosis.

Roentgenologic Findings. These are grouped as follows: Group I (50 per cent) are those of mitral stenosis with or without insufficiency. There is considerable enlargement of the right ventricle and left atrium. The pulmonary artery segment generally is prominent. There is an increase in the truncal shadows in the lungs with congestion of the peripheral ramifications. In 9 cases, the left ventricle was slightly dilated. The ascending aorta appears slightly dilated while the arch is normal or small. In Group II (16 per cent) the accentuation of the left middle arc is less marked. Pulmonary stasis, while still present, is less apparent. The right cavities and left atrium are enlarged in all cases while the left ventricle is usually moderately accentuated. The ascending aorta seems dilated with a semilunar outline. Group III (23 per cent) includes those with a typical aortic configuration. The pulmonary fields are clear and the main pulmonary arteries do not appear unusual. The right cavities are not particularly enlarged. However, there is a moderate left atrial dilatation and a definite accentuation of the left ventricle and aorta. Group IV (11 per cent) shows no definite deviation from the normal. Calcified valves, while pathognomonic, are rare.

Angiocardiography. In the presence of a predominant mitral stenosis, the right cavities are found enlarged as the result of pulmonary hypertension. In the anteroposterior view, the right ventricle occupies a considerable part of the heart shadow. The main trunk and branches of the pulmonary artery are dilated and appear much as in isolated mitral stenosis. In the levogram, along with dilatation of the left atrium which is uniformly opacified, there is also moderate enlargement of the left ventricle with a thickened wall. The proximal portion of the ascending aorta is dilated.

With predominant aortic stenosis, angiography

shows a dislocation of the infundibulum to the right and upward with a furrow on the left border of the right ventricle as the result of left ventricular hypertrophy. The pulmonary arterial circulation is not changed significantly; the veins are dilated. Delay in evacuating the arterial system is not great (four to five seconds) while the venous return can be delayed up to sixteen to twenty seconds. In the levogram, there is moderate left atrial enlargement with opacity of considerable degree and delayed evacuation and a more or less important but constant increase in the ventricle with a remarkable convexity of the medial border. The aorta is dilated particularly in the supravalvular portion reducing to normal in the descending portion.

Kymography. With aortic stenosis, there is frequently observed (1) reduced amplitude, (2) absence of differentiation of tachydiastolic and bradydiastolic characteristics, (3) lengthening of the systolic limb, (4) more or less disappearance of the isodiastolic shadow and its secondary components. There is a delay in the aortic wave as compared with the ventricle.

Pressure Studies. (1) In 24 cases, an increase in the pressure time was shown by lengthening exclusive of the deformation time or Q-I tone. This is typical of mitral stenosis. (2) In 20 cases, an increase of different degree was observed in the expulsion time or isotonic systole. In effect, aortic stenosis limits the flow in a unit time and a sufficient flow can only be obtained by a longer expulsive period.

The authors note that in none of their cases was there an aortic insufficiency.—*Marcy L. Sussman, M.D.*

Munk, J., and Lederer, K. T. Radiological observations on 33 cases of primary interstitial myocarditis during an outbreak in the Haifa area. *J. Fac. Radiologists*, Oct., 1958, *9*, 195–203. (From: X-ray Department, Rambam Government Hospital, Haifa, Israel.)

The purpose of this paper is to report the roentgenologic findings in 33 out of 61 cases of primary interstitial myocarditis in children in the age group between six months and three and one-half years which occurred in the Haifa area between May, 1956 and December, 1957. The roentgenologic features of the disease and the differential diagnosis are discussed. Of the 61 cases in this outbreak, 50 died and in 49 the diagnosis was confirmed by postmortem examination. Primary interstitial myocarditis in an adult was first described by Fiedler in 1900 and, in a child, by Zuppinger in 1901. In recent years several outbreaks of epidemic character have been reported. The etiology of the disease is unknown.

1. Size and Shape of the Heart. General enlargement of the heart is the predominant feature of the disease and it was seen in all cases. Three stages could be clearly distinguished: Stage I, slight enlargement; Stage II, marked enlargement; Stage III, extreme enlargement. In this latter, the individual heart chambers were no longer distinguishable. The heart silhouette was globular in shape with a broad base. It was almost impossible to differentiate it roentgenographically from pericardial effusion. In the cases which survived, a gradual decrease in the size of the heart over a period of months was observed with eventual return to normal.

2. Passive Pulmonary Congestion. All but 4 patients studied roentgenographically showed signs of passive pulmonary congestion on the first examination at the time of admission. Kerley's B lines were noted in and also just above the costophrenic angle, more commonly on the right side, giving evidence of lymphatic engorgement. Many cases showed marked emphysema which can be explained only by expiratory impairment. Pulmonary emphysema is a leading sign in acute respiratory infections such as acute laryngotracheitis, acute diffuse interstitial pneumonia, etc. Diffuse interstitial pneumonia is commonly seen in Israel, primary or secondary, as in whooping cough or measles. In all cases of primary interstitial myocarditis, the heart was clearly enlarged even in the presence of marked emphysema. The concomitant emphysema led the authors to assume that, in addition to myocarditis, diffuse interstitial pneumonia was present. The roentgenographic findings convinced them that prognostic deductions cannot be drawn either from the size or shape of the heart or from the degree of pulmonary congestion. Tachycardia is the first sign of relapse, followed by the reappearance of all the signs of pulmonary congestion.

3. Pleural Fluid. In all but 5 cases, pleural fluid was seen as a band-like shadow along the lateral chest wall, sometimes unilaterally, sometimes bilaterally.

4. Pulsations of the Heart. Of the 33 cases, 17 were fluoroscoped, in addition to having had roentgenographic studies, and 16 of these showed very weakened or indistinguishable heart pulsations. An important sign of the beginning of recovery was the reappearance of visible cardiac pulsations which became clearly distinguishable with the diminishing pulse rate.

5. Differential Diagnostic Considerations. The most important task of the radiologist is the differentiation between acute pulmonary inflammatory disease and primary interstitial myocarditis. In diffuse interstitial pneumonia, one of the leading signs is the marked emphysema due to expiratory impairment. The heart is small in most of the cases. The pathologic interstitial pattern is usually limited to the paramediastinal region along its whole length, leaving the peripheral or third zone free. The latter zone is usually involved in passive pulmonary congestion due to heart failure in myocarditis. Kerley's B lines were not seen in the cases of primary and secondary diffuse interstitial pneumonia. These lines are consid-

ered to be an important differential diagnostic sign, giving evidence of passive pulmonary congestion. The almost invariable presence of costal or interlobar pleural fluid in heart failure due to myocarditis is a very rare occurrence in interstitial pneumonia. In acute bronchiolitis the heart is normal and the lung fields show a fine granular miliary pattern. In acute laryngotracheobronchitis there is marked emphysema due to expiratory impairment. The heart is usually of normal size. The differential diagnosis becomes very complicated in the cases of combined diffuse interstitial pneumonia and myocarditis. Passive pulmonary congestion causes a pathologic interstitial pattern reaching into the outer lung zone. Kerley's B lines are usually present. The only definite signs of inflammatory interstitial (bronchial) involvement of the lungs is the emphysema due to expiratory impairment. When this is combined with an enlarged heart, it suggests that in addition to interstitial pneumonia, myocarditis is present. The roentgenographic differentiation between primary interstitial myocarditis and other forms of primary myocardial disease is very limited. Subendocardial fibroelastosis, which is usually seen roentgenographically at the stage of cardiac failure, presents all the clinical as well as roentgenologic signs shown in primary interstitial myocarditis. It is impossible to differentiate roentgenographically between primary interstitial myocarditis and secondary myocarditis. Generalized heart enlargement with pulmonary congestion in decompensated rheumatic carditis may present the same roentgenologic appearance as cardiac failure due to myocarditis. However, rheumatic disease of the heart does not appear during the first year of life, in which so many of the cases of primary interstitial myocarditis occurred in the reported outbreak. Decompensated congenital cardiac disease may present a very difficult differential diagnostic problem, particularly in the second half of the first year of life. The roentgenologic differentiation between primary interstitial myocarditis (Stage III of heart enlargement) and pericardial effusion may be impossible from the appearance of the heart. Pulmonary passive congestion (left heart failure) in the authors' experience is rarely seen in pericarditis.—*Samuel G. Henderson, M.D.*

Rodrigues, Dirceu, de Oliveira, Paulo Franco, and Pereira da Cunha, Gastão. Aspectos radiológicos na cardiopatia Chagásica crônica. (Radiologic aspects in chronic cardiopathy of Chagas' disease.) *Bol. Soc. Brasil. Radiol.*, Jan.–Feb., 1958, *2*, 41–50. (From: Serviço de Clínica Médica do Dr. Gastão Pereira da Cunha, Santa Casa de Misericórdia, Curitiba, Brazil.)

From the records of 150 patients, known to have or to have had Chagas' disease (South American trypanosomiasis—etiologic agent *T. cruzi*), the authors have selected 51 instances with chronic cardiopathy, yet without any other demonstrable cause for their cardiac pathology. In 34 of the 51 cases (66 per cent), there was enlargement of the heart, involving all chambers, which resembled myocardial dilatation, but neither widening of the upper mediastinum (no engorgement of big vessels) nor passive pulmonary congestion. Such findings are not characteristic in themselves, and are seen in nonspecific myocardial involvement. They may also be confused with pericardial effusion. Still, when corroborated by epidemiologic, clinical, and electrocardiographic findings, cardiomegaly without concomitant decompensation is considered sufficiently significant to warrant a presumptive diagnosis of chronic trypanosomic cardiopathy.

Ten (of the thirty) patients were subjected to autoptic examination. It revealed flaccid hearts with thin walls and dilated chambers. Myocardial fibrosis and voluminous mural thrombi were often encountered. These were presumably forerunners of parietal aneurysms.

By contrast, in 17 of the 51 cases, including 3 with autopsies, neither the roentgenologic nor the anatomic findings were in any way characteristic and no pattern could be elicited.—*E. R. N. Grigg, M.D.*

Porstmann, W., Geissler, W., and Wolf, W. Die retrograde Lävokardiographie in Verbindung mit der intrakardialen Druckmessung. (Retrograde levocardiography in connection with intracardiac pressure measurements.) *Fortschr. a. d. Geb. d. Röntgenstrahlen u. d. Nuklearmedizin*, Oct., 1958, *89*, 397–409. (From: Institut für Röntgenologie, I. Med. Universitätsklinik und Chir. Universitätsklinik, Charité, Berlin, Germany.)

Since the selective contrast filling of the left heart, either by direct puncture through the left ventricle or by puncture of the aorta through the left main bronchus, has been either followed by complications or was technically difficult, the authors have chosen the left heart catheterization through the right common carotid artery. Following local anesthesia, the right common carotid is exposed by a 2 cm. long incision. A purse-string suture is placed around the puncture in the common carotid and a catheter from 9 to 11 Charrière is passed into the ascending aorta under fluoroscopic control, using the image intensifier. From here, it is slipped during the systole into the left ventricle. A contact of the tip of the catheter with the ventricular wall elicits extrasystoles which are monitored simultaneously by electrocardiographs. As a contrast material, triopac 400 was used, 1 cc. per kg. body weight. Not more than 60 cc. was injected during two seconds. Six exposures per second were made with biplane serial changer.

Simultaneous registration of pressure readings was taken as the catheter was moved from the ventricle

into the aorta. The method was used on 17 patients in ages between four and forty-three years. The examination on children was performed under general anesthesia.

The greatest value of direct retrograde levocardiography with pressure measurements is in valvular and subvalvular aortic stenosis. The flow patterns give precise information about the extent of the ventricular septal defects with left to right shunts. A case of atrial septal defect involving also the mitral leaflet with mitral insufficiency is presented. Eight biplane reproductions of retrograde levocardiograms with electrocardiograms as well as pressure registrations in 4 cases are included among the illustrations.—*Nathan Kriss, M.D.*

Zimmerman, Charles. Esophageal stricture from the accidental ingestion of Clinitest tablets. *A.M.A.J. Dis. Child.*, Jan., 1959, *97*, 101–103. (Address: Albert Einstein College of Medicine, 1710 Newport Ave., New York 61, N. Y.)

A case is reported of esophageal stricture in a three and one-half year old girl following the accidental ingestion of a Clinitest tablet. There have been 6 similar cases reported and 5 of these were children. These tablets contain a combination of anhydrous sodium hydroxide, copper sulfate, citric acid and sodium bicarbonate. If accidentally ingested the heat produced, in addition to the caustic action of the lye, causes a thermal and chemical burn of the mucosa. This results in scarring and stricture of the esophagus.—*Thomas Dorsey, M.D.*

Abdomen

Palmer, P. E. S. Giant hypertrophic (tumour simulating) gastritis. *J. Fac. Radiologists*, Oct., 1958, *9*, 175–181. (Address: Senior Radiologist, European and African Hospitals, Bulawayo, Southern Rhodesia.)

To be able to diagnose gastritis roentgenologically has long been one of the aims of radiologists, but various physical and emotional factors make it unwise to diagnose gastritis on the appearance of the mucosa as seen roentgenographically. The same is true of gastroscopy. However, giant hypertrophic gastritis is a very definite condition which is based on pathologic findings, as well as on roentgenologic and gastroscopic investigations. Menetrier originally aptly described the distended gastric rugae in this disease as resembling the convolutions of the brain. The normal mucosal pattern is replaced by grossly distorted and hypertrophied rugae, associated with thickening of the stomach wall and a generalized increase in the size of the stomach. There are three main types roentgenologically. Group 1 is the diffuse and polypoid type involving the middle third of the stomach. Most cases fall into this group. There may be massive irregular rugae on the posterior wall and greater curvature of the stomach in one subgroup, while in a second subgroup the mucosa is so hypertrophied that the stomach appears filled with marbles, simulating diffuse or multiple polyposis. The "polypi" are due to simple mucosal hypertrophy. In each subgroup the stomach is rigid and less pliable than normally, and the peristalsis is decreased. Group 2 relates to giant hypertrophic gastritis, fundus type. This is the type described as "tumor simulating gastritis," and here one finds large tumor-like masses in the fundus of the stomach. The mucosa is smooth, with distorted pattern, as though normal gastric mucosa was stretched over an underlying tumor. Gastric ulceration is frequently associated. Group 3, the least common, is the pyloric type of giant hypertrophic gastritis. Recurrent vomiting and, frequently, pain are clinical symptoms. Roentgenologically there are gross hypertrophied mucosal folds with thickening of the distal third of the stomach wall.

At operation or on postmortem examination, all three groups are strikingly similar. The stomach is enlarged, and on palpation the sensation of feeling a bag of worms, or a varicocele is obtained. On opening the stomach the "cerebral convolutions" of the mucosa are usually reddened and covered with mucus.

The differential diagnosis from malignant disease is a problem in which gastroscopy, hematology or biochemistry is not of any help. The author states that it is a benign condition of unknown etiology for which there is no specific treatment.—*Samuel G. Henderson, M.D.*

Clarke, James S., Ozeran, Robert S., Hart, James C., and Cruze, Kenneth. Peptic ulcer following portacaval shunt. *Ann. Surg.*, Oct., 1958, *148*, 551–566. (From: The Surgical Service, Veterans Administration Center, and the Department of Surgery, University of California Medical Center, Los Angeles, Calif.)

The incidence of peptic ulcer is greater in patients with cirrhosis of the liver (18 per cent) than in the general population (8 per cent). In a series of 200 patients with Laennec's cirrhosis of which 76 bled from the upper alimentary tract, peptic ulcer was responsible in 18.4 per cent, gastric erosion in 5.3 per cent and esophageal or gastric varices in 61.8 per cent.

Portacaval anastomoses for portal hypertension may be followed by peptic ulceration. The authors report 5 cases of peptic ulcers in 62 patients following portacaval anastomoses.

Haidenhain pouches were fashioned from the greater curvature of the stomach in 9 mongrel dogs. The secretory volume of each twenty-four hour collection was determined and the total HCl output was calculated. A portacaval shunt operation was then performed. This operation was followed by an

increase in acid secretion of 92 to 850 per cent with a mean value of 344. A gastric antrectomy had no effect on the gastric secretion. With prolonged histamine stimulation, peptic ulcers were noted.

The authors suggest that the hypersecretion secondary to portacaval shunt procedures is due to secretagogues absorbed from or formed by the small intestine. The liver may normally metabolize these secretagogues, but due to the shunting of blood around the liver this does not occur and the intestinal phase of gastric secretion is augmented.—*E. C. Klatte, M.D.*

Toaiari, E., and Trenta, A. Considerazioni su un caso di fitobezoar associato con ulcera gastrica. (Considerations of a case of phytobezoar associated with a gastric ulcer.) *Ann. radiol. diag.*, 1958, *31*, No. 2, 153–158. (From: Istituto di Radiologia e Terapia Fisica, Università di Pavia, and Istituto di Radiologia, Ospedale Civile Maggiore, Verona, Italy.)

This is a case report of a twenty-one year old male patient who developed ulcer symptoms following several months of excessive ingestion of cheese. A gastrointestinal series revealed an ulcer along the lesser curvature of the pars media of the stomach and a space-filling freely movable mass within the lumen of the stomach. The diagnosis was confirmed by surgical exploration and removal of the bezoar.

The relationship of peptic ulcer and bezoar is discussed with review of the literature. The bezoars are classified as follows: (1) trichobezoar due to ingestion of animal or human hair; (2) phytobezoar due to ingestion of a variety of products of the vegetable kingdom, subdivided by Tinozzi into (a) inobezoar due to ingestion of vegetable fibers, (b) carpobezoar due to ingestion of pits or seeds of fruit and (c) orthobezoar due to ingestion of organic substances with high concentrations of minerals.

A similar case of bezoar with a gastric ulcer due to excessive ingestion of cheese was observed and reported by Lenarduzzi. Because the patient was a poor surgical risk, medical treatment was given with response of the ulcer and elimination of the bezoar. After this experience, Lenarduzzi theorized that the gastric ulcer was more likely due to the gastritis and other changes of the gastric mucosa secondary to the presence of the bezoar than to direct pressure. Thus a bezoar may create physiologic changes which predispose and favor the formation of a gastric ulcer.

It is proposed that with proper medical management and dietary restrictions the peptic ulcer will heal and the bezoar will be reduced in size and eventually eliminated from the gastrointestinal tract.

Although this medical management of peptic ulcer associated with bezoar is intriguing, complications which may occur, such as rupture of the ulcer or an intestinal obstruction with passage of the bezoar through the gastrointestinal tract, are not mentioned by the authors. In the southwestern part of this country, the largest single cause of bezoars is the ingestion of unripe persimmons and a fairly good percentage of these cases develop gastric ulcers. The reviewer is unaware that medical management alone has been successful or attempted in these cases.—*Peter E. Russo, M.D.*

Warden, M. Robert, Munro, Gordon A., and Lanier, Raymond R. Fibrous stricture of the stomach due to iron (feosol) poisoning; report of a case and brief review of the literature. *Radiology*, Nov., 1958, *71*, 732–734. (Address: M. R. Warden, 3594 Watkins Drive, Riverside, Calif.)

A late complication of iron poisoning, which is less familiar than the vomiting, diarrhea, dehydration, shock, and coma of acute poisoning, is the occurrence of fibrous stricture of the pylorus and stomach. Five such cases have been reported by the British and one is added by the authors.

The authors' case is that of a two and a half year old Negro child who ingested a number of feosol tablets and became acutely ill, recovered, and returned six weeks later with a history of vomiting for a period of two weeks. Roentgenograms of the gastrointestinal tract showed marked narrowing of the mid-portion of the stomach with some mucosal irregularity along the greater curvature which suggested ulceration. Surgery revealed an hour-glass deformity of the stomach which was repaired by the Mikulicz type of procedure. The results were good.—*W. M. McBride, M.D.*

Mestel, A. L., Trusler, G. A., Thomson, S. A., and Moes, C. A. F. Acute obstruction of small intestine secondary to hematoma in children. *A.M.A. Arch. Surg.*, Jan., 1958, *78*, 25–32. (Address: A. L. Mestel, 250 E. 58th St., Brooklyn, N. Y.)

In most cases of trauma to the abdomen the organs commonly injured are the liver, spleen and kidney. This report deals with 19 cases of hematoma of the small intestine found in the literature and the addition of 2 more cases. By far, the majority of these have been seen in the pediatric age group, following trauma to the abdomen of various degrees of severity.

The history of trauma is usually obtained immediately, but may not become apparent until further questioning. Hematologic defects appear to be of minor importance. The duodenum is prone to injury by virtue of its fixed position and its relationship to the vertebral column.

The clinical picture is nearly always characterized by abdominal pain, vomiting and leukocytosis. Abdominal tenderness is seen in approximately 50 per

cent of the cases and a palpable mass in a slightly lower percentage. The roentgenologic studies can confirm or establish the proper diagnosis.

A gastrointestinal series reveals the duodenum to be deformed and compressed. This extends over a long area and in most instances it is greater than 8 cm. Obliteration of the right psoas muscle outline is a frequent finding. The hematoma may be large enough to displace the stomach and to elevate and widen the splenic flexure.

Treatment is by surgical approach with evacuation of the hematoma or, if the diagnosis is made clinically, by conservative measures. Resection of the bowel is too radical. With either treatment the subsequent results are satisfactory.—*John L. Gwinn, M.D.*

Paterson, D. E., and Baker, S. J. The radiological investigation of the small intestine in tropical idiopathic malabsorption. *J. Fac. Radiologists*, Oct., 1958, *9*, 183–194. (From: The Christian Medical College, Vellore, Madras, South India.)

Roentgenographic abnormalities of the small bowel similar to those described in sprue, deficiency states and idiopathic steatorrhea have been found to be very common in South India.

This article deals with the roentgenographic findings in 51 such patients who were found to have malabsorption of essential foodstuffs (fat, sugar or vitamin B_{12}), without ascertainable cause for such malabsorption. The patients, all adults, complained of vague abdominal discomfort and mild diarrhea.

A colloidal suspension of barium sulfate (micropaque) was used in these studies. Normally it is expected that the jejunum will show an even, feathery distribution of barium. Transverse mucosal folds may be seen in the lower jejunum and upper ileum, but not in the upper jejunum. The ileum usually presents a smooth outline, although it may be divided by occasional areas of contraction. Normally motility in the jejunum is smooth and rapid, but much slower and more irregular in the ileum. Pathologically one may see flocculation in minor degree. This may be due to presence of mucus or abnormal fat content. Mucus has been found in the stool of 63 per cent of the cases in this series. Frazer has shown that flocculation may occur in cases of abnormal gastric or duodenal digestion, in the presence of bile-salts or in the presence of short-chain fatty acids where there is rapid change of pH values. There was roentgenographic evidence of increased caliber or of thickened mucosal folds in the small intestine in 32 per cent of all cases, a high percentage of these cases suffering from idiopathic malabsorption of essential foods. The physiologic or pathologic basis for thick mucosal folds is still undetermined. The authors believe that thick mucosal folds in the jejunum may (like the thick mucosal folds in the stomach) be caused either by inflammation, edema, allergy or by abnormal conditions of the muscularis mucosae. Abnormalities of peristalsis and transit time were found. Increased caliber of the bowel, irregular, jerky peristaltic movements, segmentation of barium pattern, slow transit time and the presence of gas in small intestine—all indicate an abnormality of the neuromuscular mechanism in the submucous wall of the intestine. In this series of cases 28 patients were found to have increased caliber of jejunum with no evidence of organic stricture detected. Almost all of these also showed evidence of thick mucosal folds. Eleven cases showed some areas of thin separated mucosal folds. There may be different stages in all these conditions where roentgenographic appearances range from thick mucosal folds with no increase in caliber to a stage where there are thin mucosal folds with increase in caliber and lack of peristaltic movements. The authors found that 90 per cent of cases finally diagnosed as idiopathic malabsorption or sprue-like disorder show roentgenographic signs.—*Samuel G. Henderson, M.D.*

Darling, R. Clement, and Welch, Claude E. Tumors of the small intestine. *New England J. Med.*, Feb. 26, 1959, *260*, 396–408. (From: Department of Surgery, Massachusetts General Hospital, Boston, Mass.)

Two hundred and twenty-five small bowel tumors were observed in the Massachusetts General Hospital from 1915 to 1957. Ninty-three were found at autopsy and 132 at operation. This study is concerned with the latter group, of which 46 tumors were benign and 86 malignant.

One hundred and thirteen of the patients who had operations performed had symptoms referable to the tumor. The major clinical patterns were those of intestinal obstruction (67 per cent), intestinal bleeding (53 per cent), an abdominal mass (31 per cent) and perforation (11 per cent). Rare findings included the deficiency syndrome, the carcinoid syndrome, the Peutz-Jeghers disease, and multiple neurofibromatosis.

A correct preoperative diagnosis was made in 84 per cent of patients who had a roentgenologic study of the small intestine.

Several diagnostic features of interest are cited: (1) tumors found incidentally at laparotomy are nearly always benign; (2) obstruction is usually chronic and remittent (when acute small bowel obstruction is due to intussusception in adults, a tumor of the intestine is involved in about one-half of the cases, and the lesion is usually benign); (3) intestinal bleeding is common with all tumors except carcinoids, in which it was encountered in only 13 per cent of the cases in this series; (4) a palpable mass nearly always indicates a malignant tumor (when the mass is tender, a lymphoma should be suspected); and (5) perforation is common with

lymphoma and sarcoma (it is rare with carcinoma and was not encountered with carcinoid or benign tumors).—*James J. McCort, M.D.*

McConnell, Fleming, Hanelin, Joseph, and Robbins, Laurence L. Plain film diagnosis of fulminating ulcerative colitis. *Radiology*, Nov., 1958, *71*, 674–682. (Address: F. McConnell, Massachusetts General Hospital, Boston 14, Mass.)

The authors discuss roentgenologic criteria upon which the diagnosis of fulminating ulcerative colitis may be based. Twenty-six cases of colitis of this type were examined which presented a striking and frequently specific appearance of the colon on plain roentgenograms of the abdomen. The utilization of the plain roentgenogram in this condition, aside from its demonstration of colonic distention, has received little attention in the past, and when one considers that barium enema studies are often precluded due to the severity of the illness and the frequency of perforation, the value of these frequently distinctive findings on the plain roentgenogram is quite evident. The symptomatology, pathology, and most dangerous complication, that of perforation, are considered.

Roentgenologically, the morbid anatomic changes of distention and shortening of the colon, irregular thickening of the bowel wall, nodular mucosal elevation, and intervening thinning or ulceration may produce the appearance that is diagnostic of fulminating ulcerative colitis. In supine roentgenograms, the colon is seen to contain an excess of gas, with the transverse colon showing the most marked distention. Thickened inflamed mucosa forms irregular nodules which protrude into the air-filled lumen and cause the outline of the gas shadow to be irregular, nodular, or scalloped. When seen en face, the bowel wall has a mottled or cobblestone appearance, due apparently to contrast between inflamed thickened mucosal islands and the adjacent thinned ulcerated areas. Retained fecal matter, more commonly in the cecum and ascending colon, may obscure changes in the bowel wall, but the left half of the colon usually contains only gas, and thus permits more adequate visualization of the changes in the wall. Thickening may also be demonstrated on plain roentgenograms as a separation of the faint radiolucent line of pericolic fat from the gas-filled lumen.

The foregoing abnormalities in the plain abdominal roentgenogram were found in 16 of the 26 cases seen by the authors. In the remaining 11 cases, only colonic and small bowel distention without specific alteration in the bowel wall was seen. Repeated abdominal roentgenograms of the patients showing only distention on the original film will frequently bring out previously unseen changes in the wall. The authors feel that when distention alone is seen, it cannot be distinguished from ileus of other origin, but if there is clinical evidence of active colitis, the demonstration of a markedly distended colon on plain roentgenograms of the abdomen should be interpreted as possible evidence of severe colitis. Brief clinical summaries of the illustrated cases are included.—*John S. Alexander, M.D.*

De Andrade, Hugolino L. Possibilidades radiodiagnósticas da colecistocolangiografia endovenosa. (Diagnostic roentgenologic possibilities of intravenous cholecystocholangiography.) *Bol. Soc. Brasil. Radiol.*, Dec., 1957, *1*, 169–190. (Address: Livramento, Rio G. do Sul, Brazil.)

Based on over 700 personal observations, the author suggests the following indications for intravenous injection of biligrafin, with the intent to demonstrate either the gallbladder or the biliary ducts or both: (1) In cholecystectomized patients; (2) after nonvisualization by peroral administration of cholecystographic medium; (3) to evaluate the biliary ducts in the presence of cholelithiasis; (4) when immediate visualization of the gallbladder is required (such as prior to emergency surgery); (5) in children (visualization of the gallbladder does not occur before two to three hours); and (6) in icterics. In the presence of bilirubinemia above 10 mg. per cent, the injection of biligrafin will not produce visualization of the biliary ducts, and should be postponed until lower levels of bilirubin in the blood are reached. The only real contraindication for intravenous cholangiography is sensitivity to iodine.

Reports in the literature mention the use of many drugs in connection with biligrafin. In this paper, it is stated that when incompetence of Oddi's sphincter prevents satisfactory visualization of the ducts, the examination may be repeated after forty-eight hours, at which time morphine is given to close the sphincter. Furthermore, it appears of advantage to recommend a fatty meal (coffee with cream and buttered sandwich) about one hour prior to the intravenous injection; this is assumed to empty the biliary channels. When high bilirubinemia persists, an attempt may be made to "flush" it out with hypertonic dextrose, associated with insulin, ascorbic acid, and morphine sulfate.

This interesting paper contains impressive reproductions of calcified hydatid cysts in the liver, a finding which is supposedly not so uncommon in South America. Moreover, filling defects in the common duct caused by hydatid membranes are said to be indistinguishable from those produced by calculi.—*E. R. N. Grigg, M.D.*

Salzman, Emanuel, Spurck, Robert P., Kier, Lawrence C., and Watkins, David H. Opacifying gallstones. *J.A.M.A.*, Jan. 24, 1959, *169*, 334–338. (Address: E. Salzman, City and County of Denver Department of

Health and Hospitals, West Sixth Avenue and Cherokee Street, Denver, Colo.)

Certain gallstones become roentgenographically opaque after prolonged exposure to a cholecystographic contrast medium, with or without visualization of the gallbladder or bile ducts. These calculi are called "opacifying gallstones."

Patients whose gallbladders could not be visualized or could be visualized only faintly after the conventional examination with 3 gm. of iodopanoic acid were studied by prolonged administration of iodopanoic acid (telepaque). These patients were placed on a four day regimen of 3 gm. of contrast medium per day, 1 gm. after each meal. A relatively fat-free diet was given during this time. On the morning of the fifth day the examination was made with the patient fasting.

The authors examined 123 patients with this test. In 76 there was probable or proved calculous biliary tract disease, while 32 had noncalculous biliary tract disease and 15 had a normal biliary tract. The test is considered to be the best method of demonstrating bile duct stones in the presence of jaundice.

The gallstone opacification phenomenon has been produced *in vitro* and is due to a reaction between biliverdin on the surface of the stones and the constrast medium in the bile.—*James J. McCort, M.D.*

Gynecology and Obstetrics

Youssef, Abdel Fattah. The uterine isthmus and its sphincter mechanism, a radiographic study. I. The uterine isthmus under normal conditions. *Am. J. Obst. & Gynec.*, June, 1958, *75*, 1305–1319. (From: The Department of Obstetrics and Gynecology, Kasr-el-Aini Hospital, Cairo University, Cairo, Egypt.)

The concept of an isthmus as a distinct part of the uterus 8 to 10 mm. in length lying between the body and the cervix was introduced by Aschoff. He described it as bounded superiorly by the orificium internum anatomicum and inferiorly by the orificium internum histologicum. Stieve and Frankl found that the mucosa of the isthmus differed from that of the corpus in the various phases of the menstrual cycle. Most investigators agree that a functional sphincter exists at the junction of the corpus uteri. The authors studied this area in its normal and abnormal state.

Sixty normal women were examined, including 3 who were postmenopausal, 2 in early pregnancy, and 55 nonpregnant women in the childbearing age of whom 34 were multiparous and 21 parous. Forty of the 55 nonpregnant women were examined by isthmography, a technique utilizing a Jarcho cannula with special rubber cones to efficiently close the external os, and the slow injection of 4 or 5 cc. of warm lipiodol into the lower uterine segment. In 16 cases isthmography was carried out in the follicular phase, and in 12 cases during the luteal phase. In addition, direct hysterography was performed on 15 normal nonpregnant women, 5 in the follicular phase, 5 in the luteal phase, and 5 one or two days before the onset of menstruation. This technique consisted of injecting exactly 2 cc. to 2.5 cc. of lipiodol through the uterine wall into the uterine cavity by means of a fine lumbar puncture needle, either through the posterior fornix, or a small posterior colpotomy.

In all cases the isthmic canal was visualized on the roentgenograms as a distinct segment of the uterus narrower than the cervical canal below and the corporeal cavity above. There was no difference in multiparous and parous women. The isthmic canal is bounded by a definite constriction superiorly, the superior isthmic sphincter, and inferiorly by the inferior isthmic sphincter. Both constrictions are equal in size. During the follicular phase, the canal is cylindrical, during the luteal phase it is longer and narrower. In the 2 days prior to menstruation, the isthmic segment becomes shorter and wider and the superior and inferior sphincters relaxed. It was more relaxed in postmenopausal patients and tightly constricted in pregnant patients.

On direct hysterography, oil remained in the uterine cavity above the isthmus one to three hours in the follicular phase, and four to eight hours in the luteal phase. The oil emptied into the peritoneal cavity through the tubes and none into the vagina during the luteal phase. The oil was retained for only ten to thirty minutes in the cases studied one to two days prior to menses, and then emptied through the cervix into the vagina.

The authors ascribe these physiologic changes in the isthmus to hormonal actions. The isthmus is functionally most contracted during the luteal phase and most relaxed immediately before and during menstruation. The uterine corpus, on the contrary, is least active during the former phase and most active during the latter. The coordinated activity of these 2 segments is fundamentally important for normal functions of fertilization, nidation, maintenance of pregnancy and menstruation.—*J. A. Campbell, M.D.*

Youssef, Abdel Fattah. The uterine isthmus and its sphincter mechanism, a radiographic study. II. The uterine isthmus under abnormal conditions. *Am. J. Obst. & Gynec.*, June, 1958, *75*, 1320–1332. (From: The Department of Obstetrics and Gynecology, Kasr-el-Aini Hospital, Cairo University, Cairo, Egypt.)

Very little is known about the role of the uterine isthmus in pathologic conditions. Forty abnormal cases were studied by isthmography and direct hysterography to evaluate the functional importance of this area.

In cases of secondary amenorrhea, the isthmic

canal was wider than normal and both the superior and inferior isthmic sphincters were relaxed. When progestin was given after priming with estrogen, the isthmic canal always became markedly narrower and the sphincters more tightly closed. Progestin contracted the superior isthmic sphincter in one patient with amenorrhea and low estrogenic function, while the rest of the isthmus remained unchanged.

The cases of anovular menstruation showed dilated isthmic segments with relaxed sphincters one week before the period. The isthmic canal was very wide in cases of metropathia hemorrhagica and the polypoid endometrium stopped sharply at the level of the superior isthmic sphincter.

Five of 6 cases of habitual abortion of the second trimester showed the typical picture of a dilated incompetent isthmus, even in the luteal phase. No difference was noted in the appearance of the isthmus in cases of primary and secondary abortion.

The 12 cases of dysmenorrhea showed no deviation from normal in the follicular or luteal phase, but examination one or two days before the period showed no shortening and widening of the isthmus, as is normally seen.

The direct hysterography in 3 patients subject to habitual abortion showed immediate leakage of oil into the vagina from the uterus in the luteal phase, a finding never seen in normal subjects.

From these studies it was postulated that narrowing of the isthmus during the luteal phase of the normal cycle is due to progestin secreted by the corpus luteum. Estrogen widens the isthmus, as seen in the cases of hyperestrogen menorrhagia. It also explains the painless bleeding of anovulatory menstruation. The author believes that traumatic or dysfunctional incompetence of the uterine isthmus accounts for the occurrence of habitual abortion, rather than incompetence of the cervix or internal os and points out that amputation of cervix is not followed by habitual abortion unless it is amputated above the internal os. He also believes that dysmenorrhea is a matter of incoordinated uterine activity due to contracture of the isthmus and inferior isthmic sphincter when the corpus is actively peristaltic and cannot evacuate itself. The pain originates in the richly innervated isthmus and is due to stretching and incoordinate dilatation of its sphincter system. The basic abnormality in primary dysmenorrhea is thought to be a failure of normal relaxation of the isthmus in the immediate premenstrual period and at the beginning of menstruation due to temporary hormone imbalance or abnormal response of the isthmus to normal endocrine influences.—*J. A. Campbell, M.D.*

Genitourinary System

Harrow, Benedict R, and Sloane, Jack A. Aneurysm of renal artery: Report of five cases. *J. Urol.*, Jan., 1959, *81*, 35–41. (Address: B. R. Harrow, 2621 Biscayne Blvd., Miami, Fla.)

In recent years an increase in the number of aneurysms of the renal artery has been reported in the literature. Exclusive of arteriovenous aneurysms, the total number of true and false aneurysms recorded amounts to 169. Of these, 69 were calcified true saccular aneurysms and 100 noncalcified true and false aneurysms. Twenty-four cases of ruptured aneurysms, all of the noncalcified type, have been described. Six of these appeared during pregnancy.

The authors add 5 new cases of saccular aneurysm and indicate the value of aortography in the diagnosis of these lesions. One aneurysm developed in a solitary kidney, and this is the third one of this type reported in the literature. Noncalcified aneurysms demand operation, since rupture frequently occurs. Calcified aneurysms in elderly, asymptomatic, normal tensive individuals do not require surgical intervention. Surgery is indicated if pain, hematuria, hypertension or renal impairment occurs in any patient with a demonstrable renal artery aneurysm. Whenever typical ring calcifications are identified in the region of the renal hilus, translumbar aortography should be utilized, since this is a safe procedure when properly performed.—*George W. Chamberlin, M.D.*

Glazier, McCleery, and Lombardo, Louis J., Jr. Diseases of renal artery. *J. Urol.*, Jan. 1959, *81*, 27–34. (Address: M. Glazier, 2010 Wilshire Blvd., Los Angeles 57, Calif.)

Systemic hypertension may be the result of renal vascular or renal parenchymal disease. The authors classify lesions of the renal artery as arteriosclerosis, aneurysm, congential deformity, embolism, and extrinsic lesions which produce distortion of the renal artery. Case reports are included to illustrate the various lesions in this classification. The value of aortography in conjunction with the other customary methods of studying renal function is pointed out.

The authors believe that every patient with an elevated blood pressure should have as complete an initial study as is practical. Several clinical groups may be suspected of having a definitive cause for hypertension. These are: (1) patients under thirty-five years of age; (2) older patients with a sudden onset of severe hypertension; and (3) patients who have sudden onset of hypertensive disease associated with pain in the flank.

The treatment consists either of removal of the offending kidney or repair of the damaged vessel.—*George W. Chamberlin, M.D.*

Winter, Chester C. A new test for vesicoureteral reflux: An external technique using radioisotopes. *J. Urol.*, Jan., 1959, *81*, 105–111. (From: The Department of Surgery,

Division of Urology, University of California Medical Center, Los Angeles; Wadsworth General Hospital, Veterans Administration Center, Los Angeles; and the Paraplegic Section, Veterans Hospital, Long Beach, Calif.)

The author describes experimental and clinical studies of a tracer technique for determining reflux.

The preliminary studies were carried out after cystoscopy and ureteral catheterization, at which time a radioactive agent was instilled through the catheters into the kidney. Gamma-ray scintillation counters were directed over the anterior aspect of each kidney with the patient in the supine position and a continuous record was obtained of the amount of irradiation emanating from each kidney. Subsequently, 25 patients were utilized both experimentally and in the clinical application of the test.

Two types of radiation detection equipment were used. The first consisted of lead shielded scintillation counters, rate meters, and Esterline-Angus recorders; one such unit for each kidney. Some modifications were made in the lead shielded counters by adding an aditional inch of lead in the later studies.

The second type of equipment was the same excepting for the substitution of medical spectrometers for the rate meters. The radioisotopes used were rose-bengal I^{131} and diodrast I^{131} in doses of 3 to 7 μc. The experimental studies showed that secondary ionization effect from the opposite kidney could be overcome by using single channel spectrometers in place of the rate meters. An alternate method consisted of the addition of lead shielding to the crystals of the scintillation counters for protection against scattered radiation.

Reflux of bladder contents into the ureters is considered to be abnormal in adults. It is often found secondary to neurogenic bladder dysfunction, cystitis, lower urinary tract obstruction, and after surgical procedures on the bladder. Previous methods of detecting such abnormality have been chiefly by instillation of a radiopaque medium into the bladder followed by periodic roentgenograms. This procedure has certain disadvantages in that it is not continuous, and also, it exposes the patient to some degree of irradiation. The present method, which the author recommends, overcomes both of these disadvantages and is a satisfactory procedure for evaluating abnormal physiology of the lower urinary tract.

Eleven figures are included.—*George W. Chamberlin, M.D.*

Nervous System

Rugh, Roberts. Responses of the developing fetal nervous system to roentgen irradiation. *Radiology*, Nov., 1958, *71*, 729–731. (Address: 630 West 168th St., New York 32, N. Y.)

It is known that developmental abnormalities can be produced in the embryo or fetus by ionizing radiations which interfere with the normal biologic process of cell division and differentiation. Studies on the neural retina of the mouse embryo have shown that these abnormalities are produced by injury to the embryonic differentiating neuroblasts which are believed to be the most radiosensitive of all cells. These damaged cells are discarded by the early embryo and are replaced, as best as possible, by the remaining undamaged undifferentiated and less radiosensitive cells. These latter cells which may be quite normal with regard to structure and function will continue to develop following irradiation, and may result in a topographically normal but quantitatively reduced organism, particularly deficient in neural elements. The functional deficiency will depend on the stage of development and on the degree of insult. Because of these factors the author feels that roentgen irradiation of the human embryo or fetus should be discouraged, particularly during the first trimester. —*Donald N. Dysart, M.D.*

Radioisotopes

Veraguth, P. Die Therapie der Sturma maligna. (The treatment of struma maligna.) *Radiol. clin.*, Sept., 1958, *27*, 293–308. (From: Röntgeninstitut des Inselspitals und der Universität, Bern, Switzerland.)

All patients with malignant tumors of the thyroid gland are given 100 to 200 μc of I^{131} by mouth to determine the uptake of the tumor in the thyroid gland, as well as the relation of that uptake to other regions of the body for detection of possible metastases. The scintigram usually shows less uptake by the tumor area in comparison to normal thyroid tissue, although this does not differentiate a malignant from a benign new growth. Several examples are given, with scintigrams locating the distant metastases.

The more differentiated the carcinoma and the easier to demonstrate follicle formation, the greater the possibility of iodine storage in the carcinoma. The metastatic adenoma and the adenocarcinoma with follicle formation take up iodine most frequently, while the undifferentiated carcinoma, the sarcoma, and the Hürthle-cell adenoma show practically no iodine uptake. The uptake in the neoplastic tissue never assumes the amount shown by the normal thyroid gland. After inactivation of the normal thyroid tissue, the iodine uptake of the neoplastic cells, which previously showed no uptake at all, is not altered. In many patients with metastases, not only do not all such foci take up the same amount of iodine, but the amount can change from months to years. Areas that never showed an uptake may suddenly do so, and vice versa. To prevent the danger of tumor dissemination which may result after

biopsy of the thyroid tumor, a tracer dose of radioactive iodine is given twenty-four hours before the operation. The removed tissue can also be studied for iodine uptake by autoradiographs. Carcinoma of the thyroid, regardless of the histologic appearance, shows a better prognosis in patients under the age of forty years and especially in children.—*Samuel Richman, M.D.*

Maurer, Hans-Joachim. Die Therapie der Struma maligna. (Treatment of struma maligna.) *Radiol. clin.*, Sept., 1958, *27*, 309–319. (From : Röntgeninstitut des Inselspitals und der Universität, Bern, Switzerland.)

Seventy-three malignant thyroid gland tumors were treated since 1947. Only in 2 instances were a malignant tumor and hyperthyroidism coexistent. Most of the patients came to operation with a diagnosis of simple goiter, since the exact diagnosis seems impossible without histologic examination. Preoperative irradiation should always be considered when there is a suspicion of a malignant tumor, and especially when the tumor is growing rapidly. A dose of 1,500 to 2,000 r is suggested, to be followed immediately by surgery. Postoperative irradiation must not be omitted. Even when the tumor shows iodine uptake, I^{131} should not be used preoperatively, as a protection for the operator from radiation.

Malignant thyroid tumors should be treated by operation followed by irradiation, since successful I^{131} therapy can be carried out in relatively few cases. The entire neck including the regional lymphatics is treated through 2 to 4 fields for a tissue dose of 4,000 to 6,000 r. If, after roentgen therapy, tracer studies show sufficient uptake by the residual thyroid tissue, I^{131} may be used. Before local tumor treatment is begun, I^{131} tracer studies are carried out to detect metastases. Only in 4 of 24 patients with metastatic foci was iodine uptake demonstrated adequately. If the metastases do take up iodine, I^{131} is given in one of two ways: 100 to 150 mc repeated every ten to twelve weeks, with doses up to 650 mc, or 20 to 25 mc at short intervals. If no iodine uptake is demonstrated, roentgen therapy with doses of 3,000 to 4,000 r is administered. Metastases may regress to a similar extent and in the same time period after roentgen as after I^{131} therapy. The contraindications for I^{131} treatment are metastases to the bone marrow (proven by bone biopsy) and small, scattered metastatic foci in the lungs showing iodine uptake. In the former, there is danger of severe bone damage, and in the latter, of marked lung fibrosis.

It has been demonstrated by some investigators that the elimination of all thyroid gland tissue leads to an overproduction and oversecretion of the thyrotropic hormone in the pituitary gland. Since this hormone stimulates the growth of the differentiated thyroid tumors, should hypophysectomy be done when metastases are found?—*Samuel Richman, M.D.*

Boyd, Julian D., Morgan, Leslie A., and Blum, Alvin. The use of radioisotopes in the clinical study of renal function. *South. M. J.*, Jan., 1958, *52*, 1–6. (From: The Veterans Administration Hospital, Coral Gables, Fla.)

Diodrast labelled with I^{131} has been used to study renal function since 1956 when it was described by Winter. The authors perform the test by injecting intravenously 0.4 μc of I^{131} diodrast per kg. of body weight. The radioactivity is determined by using a complete counting system for each kidney consisting of a collimated probe scintillation detector, count rate meter and rectilinear recorder. The detectors are placed over the kidneys with the patient sitting and leaning forward, so as to minimize the activity from other structures. The test takes about 20 minutes.

The renogram obtained as above can be divided into 3 phases. The initial rise in activity is due to the I^{131} diodrast in the vascular bed (*vascular phase*). The next rise in activity represents the tubular secretion (*secretory phase*). The *excretory phase* begins when the rate of drainage surpasses the maximum rate of tubular secretion. The activity gradually declines and a plateau is reached. The right and left renograms are qualitatively similar in the normal. The right renogram is at a higher level of activity than the left due to the liver background. Changes in vascularity, tubular secretion and drainage can be detected.

A normal renogram and 9 abnormal renograms are presented to show the characteristic changes. The abnormalities are: absence of a kidney, partial ureteral obstruction and hydronephrosis, nonfunctioning kidney, complete ureteral obstruction, acute pyelonephritis, right renal embolus, chronic pyelonephritis and contracted kidney, and compression of one kidney due to lymphosarcoma.

I^{131} diodrast renography is a good screening procedure and supplements the other renal function tests. It is of value in hypertension to determine if there is unilateral renal disease. The amount of radiation received by the patient is negligible—*Charles W. Cooley, M.D.*

Jaimet, C. H., Tomlinson, R. H., and Nace, P. F. Inhalation radiocardiography. *Canad. M. A. J.*, Dec. 15, 1958, *79*, 972–977. (Address: C. H. Jaimet, 508 Medical Arts Bldg., Hamilton, Ontario, Canada.)

This interesting work is written in two parts, of which the second is an addendum submitted at a later date than the body of the paper. Since methods and conclusions found in the body of the paper differ considerably from those in the addendum, the latter portion is stressed in this review.

Tracers used were 15 μc of methyliodide tagged with I^{131}, or 5 mc of krypton 85, inhaled by the pa-

tient from a closed system. Simultaneous counts were made over the heart and right lung by two directional scintillation probes and the data from the counting rate meters were charted by a four pen recorder, together with simultaneous recordings of the cardiac and respiratory cycles. Considerable difficulty was encountered in separating the true heart count from the contribution by underlying pulmonary circulation. Observations were made over a period of thirty to sixty seconds after initial inhalation.

The data were anlayzed by plotting the log of the counting rate against the time in seconds. The resulting curve shows an immediate rise in radioactivity on the first inhalation, while the descending limb was of varying duration and possessed one or two components, with a marked change of slope in some cases at fifteen to thirty seconds. The rate of accumulation and decay of radioactivity were obtained from the solution of simultaneous equations, and the first and second exponentials of the desending limb of the curve were plotted graphically and calculated. A normal curve apparently consists of a rapid upward rise on the first inhalation followed by an excretion curve of uniform slope and lower final altitude than an abnormal one.

A two-part excretion curve, with a change in slope in the descending limb, has always been observed in curves plotted from data obtained in patients known to be suffering from heart disease. In only one instance has this sort of excretion curve been detected in a normal subject. Another feature of the abnormal excretion curve seems to be a higher final altitude, suggesting retention of tracer material in the pulmonary vascular system and cardiac blood pools. However, it is stated that none of the cardiac patients who showed delay in excretion of the tracer material was known to be suffering from pulmonary disease or pulmonary vascular congestion. The findings cannot otherwise be explained at this time, but more work is being done. This new procedure is an interesting one, but its ultimate value cannot as yet be estimated.—*Frederick J. Bonte, M.D.*

Harper, Paul V., Lathrop, Katherine A., Baldwin, Louis, Oda, Yoshio, and Kryshtal, Lidia. Palladium 103: A new isotope for interstitial implantation at operation. *Ann. Surg.*, Oct., 1958, *148*, 606–615. (From: The Department of Surgery, University of Chicago and the Argonne Cancer Research Hospital, Chicago, Ill.)

This is a preliminary report concerning the production and calibration of a new isotope, palladium 103, along with some preliminary dosimetric, distribution, and histologic studies. This isotope is felt to combine the ease and safety of handling of a beta emitter with the even radiation field produced by a gamma emitter.

However, palladium 103 requires the availability of a very high thermal neutron flux for its production. It is felt that with the advances in reactor technology the problem of production will be eased in the near future. At the present time a thermal neutron flux of 10^{14} neutrons/cm.^{2} per second is available at the Materials Testing Reactor in Idaho.

Palladium 103 has a half-life of seventeen days and decays by electron capture. This is accompanied by a number of very weak gamma rays with intensities of 10^{-3} to 10^{-6} photons per disintegration, which are negligible from the point of view of radiation dosage. For practical purposes, only the 20 kv. radiation of the daughter isotope, rhodium 103, and the 37 kv. radiation of the conversion electron are of any significance.

Palladium 103 is produced by irradiation of palladium metal. In the production, iridium which has a long half-life, if found as an impurity, must be eliminated by glyoxime precipitation from the final product. Also silver 111 is present and must be precipitated out. Assay of the palladium is carried out by determining the silver 111 content after separation from the palladium.

Palladium 103 may be used as a solution in small quantities in plastic applicators or as precipitated palladium black injected into tissues as a suspension. When used as a suspension, if it is combined with 6 per cent gelatin there is very little reaction of the tissue to the injected material. It has been calculated that a relatively even dose distribution is maintained with this isotope when contrasted to a beta emitter used under similar circumstances. It is also felt that palladium 103 used as a suspension gives a more effective radiation field than Au^{198}, as well as avoiding the disadvantages of dealing with gamma radiation.

Animal experiments and methods of dosage calculations are also discussed.—*Earl Robert Brown, Jr., M.D.*

Azarnoff, Daniel L., Curran, George L., and Williamson, William P. Incorporation of acetate-1-C^{14} into cholesterol by human intracranial tumors *in vitro*. *J. Nat. Cancer Inst.*, Dec., 1958, *21*, 1109–1115. (From: Departments of Medicine and Surgery, University of Kansas Medical Center, Kansas City, Kans.)

Viable brain tissue was obtained at the time of craniotomy and was incubated with sodium acetate labelled C^{14} and, following a series of steps, the cholesterol was purified as the dibromide and its radioactivity determined with an end window Geiger-Müller tube. Normal brain tissue was unable to synthesize cholesterol whereas astrocytomas, globlastoma multiforme, neurofibromas, meningiomas, acoustic neurinomas and ependymomas were able to do so. The synthetic pathway of cholesterol production is thought to be the same in brain tumors as in the normal liver.

An adenocarcinoma of the sigmoid colon was studied for comparison, and the synthesis of cholesterol was found to be not rapid enough to account for its concentration in the tumor; therefore, it was assumed that the tumor must draw on the supplies of the host for the cholesterol.

Vanadium administered orally as diammonium oxytartratovanadate was found to inhibit the production of cholesterol in brain tumors. Deep roentgen therapy in 1 case did not inhibit the synthesis of cholesterol. Preliminary studies evaluating vanadium as an inhibiting agent in therapy of brain tumor show that it is not an effective antitumor compound. The tumors most likely draw on the circulating blood pool for their cholesterol supply.—*Charles W. Cooley, M.D.*

CHEMOTHERAPY

Hertz, Roy, Bergenstal, Delbert M., Lipsett, Mortimer B., Price, Edward B., and Hilbish, Theodore F. Chemotherapy of choriocarcinoma and related trophoblastic tumors in women. *J.A.M.A.*, Oct. 18, 1958, *168*, 845–853. (From: National Cancer Institute, Bethesda, Md.)

Based on a known high requirement of fetal and maternal tissues for folic acid for their normal metabolism, the therapeutic potential of a folic acid antagonist, 4-amino-N^{10} methyl pteroylglutamic acid (methotrexate) in the treatment of choriocarcinoma and related trophoblastic tumors was studied in 27 women. All patients presented unequivocal roentgenologic, hormonal, or clinical evidence of disseminated trophoblastic disease. They were treated according to a specially devised, intensive regimen in which the methotrexate was given in five-day courses at a daily dose of 10–30 mg., usually administered intramuscularly, but in some instances by continuous intravenous drip. Therapeutic indexes included: (1) serial chest roentgenograms; (2) physical findings reflecting pelvic, cerebral, and pulmonary involvement; and (3) frequent quantitative determinations of the urinary excretion of chorionic gonadotropic hormone.

The treatment itself involved a substantial hazard as the drug's side effects of stomatitis, bone marrow depression, drug rash, gastrointestinal irritation, and rarely, a toxic hepatitis were often severe and not always reversible. The maximum clinical toxicity was most frequently encountered from four to seven days after the completion of a five-day course. Successive courses of therapy were not begun until all prior signs of toxicity had subsided. Contraindications to intensive therapy included preexisting hepatic or renal dysfunction (as methotrexate is excreted largely in the urine) and residual bone marrow depression following other forms of therapy.

Of the 27 patients, remissions varying from twenty-nine to two months were induced in all but one patient, *i.e.*, 22 patients, who had received more than one course of therapy. In five patients these continuing remissions were attended by no roentgenologic, physical, or hormonal evidence of residual disease. In 11 patients showing an initial remission, methotrexate resistance has been encountered, with varying manifestations of persistent or progressive disease. Six patients initially responded but subsequently developed resistance to methotrexate and died. One patient died of drug toxicity during remission, and drug toxicity may have contributed to the death of two other severely debilitated patients.

These experiences demonstrated that metastatic trophoblastic disease is susceptible to treatment and that significant clinical remissions may be obtained. Hence, although the chemotherapeutic regimen is somewhat hazardous, the morbidity and mortality must be regarded as acceptable at the present time. —*Donald M. Monson, M.D.*

Freiberger, Robert H., Kammerer, William H., and Rivelis, Abraham L. Peptic ulcers in rheumatoid patients receiving corticosteroid therapy. *Radiology*, Oct., 1958, *71*, 542–547. (Address, R. H. Freiberger, 535 East 70th St., New York 21, N. Y.)

The authors report the findings of a study of peptic ulcers in patients receiving corticosteroid therapy as to incidence, distribution, location and roentgen appearance. Over a period of twelve months, upper gastrointestinal studies were done on rheumatoid patients who had been maintained on corticosteroid therapy for periods of six months or more. Of 114 such patients, 35 or 31 per cent had peptic ulcers. In a small control series of 33 patients with the same disease, but not receiving corticosteroids, only 3, or 9 per cent had ulcers. Of the 35 ulcers, 4 represented reactivation of previously known ulcers and 31 were new. The ulcers developed with equal incidence in males and females and appeared to occur more frequently in patients having moderately severe to severe rheumatoid arthritis. In patients who had received corticosteroid therapy over six months, the length of treatment did not appear to be of consequence. Ten patients with ulcers had no symptoms referable to the gastrointestinal tract and in the remaining 25, the symptoms were minimal.

Despite the paucity of symptoms, 4 patients had gross bleeding and 3 had stools which were persistently positive for occult blood. Six patients had an episode of acute abdominal distress and 3 of these required surgery. In 2 cases acute perforation of an ulcer had occurred. Five of the 35 ulcers were located in the duodenum, or 1 duodenal ulcer to 6 gastric ulcers which is an unusual distribution. All but 2 of the gastric ulcers were found in the antrum, 8 at the greater and 20 at the lesser curvature. Most of these ulcer craters were shallow with the diameter

of the crater much greater than the depth. In most cases, rugal folds radiated from the crater, and there was an unusual flexibility to the underlying gastric wall and surrounding area.

Neither pylorospasm nor duodenal irritability was noted and peristaltic waves passed the area of the ulcer with no deformity. Carcinoma of the stomach was not encountered in this series, although in some cases, healing of the ulcer was extremely slow. Two patients received roentgen therapy to the stomach causing a temporary achlorhydria and healing of the ulcers ensued. The ulcers recurred, however, after a return to steroid medication although only a minimal amount of free acid was present.—*John S. Alexander, M.D.*

Block, Matthew. Histopathologic effects of x-rays, radiophosphorus, nitrogen mustard, urethane, and steroids upon the spleen in leukemias and lymphomas. *Radiology*, Oct., 1958, *71*, 477–501. (Address: 4200 E. Ninth Ave., Denver 20, Colo.)

The purpose of this study is to investigate the histopathologic effects of treatment of leukemias and lymphomas by comparing the morphology of biopsy specimens of the spleen, obtained following treatment, with a control biopsy obtained immediately prior to therapy. The histopathology of the biopsy specimens is described in detail, including pre-treatment and post-treatment specimens from 9 patients who received roentgen therapy, 3 who received radiophosphorus, 1 who received urethane, 5 who received nitrogen mustard, 4 who received steroid therapy, and 1 each who received combined therapy of cortisone and radiophosphorus or urethane and roentgen therapy.

The changes produced by roentgen rays, radiophosphorus, urethane, and nitrogen mustard were similar, and combinations of therapy apparently resulted in a summation of effect. Steroids differ from the above agents in their ability to cause reversion of the spleen of patients with acute myelogenous leukemia toward normal structure. More important though, in each patient there was always some histologic evidence of the disease regardless of the completeness of remission as determined by subjective or objective grounds. With very rare exceptions, the acute changes following cytocidal therapy were limited to twenty-four or forty-eight hours after a single dose or treatment. These changes vary from minute to moderate in degree, and in general do not parallel the degree or duration of remission, suggesting that some factor other than decrease in amount of abnormal tissue is operative. There was excellent evidence to indicate that irradiation and radiomimetic drugs had no effect on the reticular cells and stem cells, or upon dividing cells, contrary to the much quoted laws of Bergonié and Tribondeau. There was no evidence that any single treatment or even course of therapy induced a significant fibrosis. Hemosiderosis, if already present, was unaltered except in those patients receiving many transfusions.

It is suggested that further lines of investigation be directed toward (1) the mechanism controlling the differentiation and maturation of hematopoietic cells, (2) the factors involved in the regeneration of malignant tissue after a successful remission, and (3) induction of development of normal tissue instead of solely searching for a means to destroy the cell or cells which are only secondary or tertiary manisfestations of the malignant process.—*Walter H. Jarvis, Jr., M.D.*

Ely, Charles A. Regulation of ovarian response to irradiation by gonadotrophic antiserum. *Anat. Rec.*, July, 1958, *131*, 429–443. (From: Department of Anatomy, College of Physicians and Surgeons, Columbia University, New York, N. Y.)

This represents an extension of work previously reported by the author.

In female mice, estrogen function is suppressed following irradiation and this apparently leaves the pituitary uninhibited in its production of gonadotrophic hormone. The resulting excess of this hormone leads to stimulation of the ovary with resulting tumor formation and to enlargement of the uterus.

The author developed an antiserum which inhibits the gonadotrophic hormone and which he administered to female mice at varying intervals after irradiation. He was then able to show in most of these mice, involutional and regressive changes in the ovaries and uteri not usually seen under these circumstances.—*Henry J. Klos, M.D.*